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Ethnomedicinal Importance of Pteridophytes from Jhargram District, West Bengal, India.

Tridib Kumar Sahoo

Assistant Professor, Department of Botany
Tamralipta Mahavidyalaya,
Tamluk, Purba-Midnapore. W.B., India.
E-mail: tksahoo.botany@gmail.com.

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Abstract :

An ethnomedicinal survey of pteridophytes in eight blocks of Jhargram District of West Bengal, was carried out to collect the folklore information by way of discussions (verbal communication) with the traditional medicine men of the area, locally known as 'Ojha' and also with the elderly knowledgeable rural ethnic people. A list of pteridophytes used by local healers was compiled during this survey. In this study it was seen that 12 species of pteridophytes under 6 families are generally used as medicine by different tribes of Jhargram district. These are used to cure different disease in the form of decoction, powder, paste, juice and extracts. The whole plant or plant parts such as root, rhizome and leaf are used as medicine. Some of these species are gradually destroyed, so it must need immediate attention for their conservation.

Key words – Ethno-medicine, folklore, ojha, Jhargram district.

Introduction

The importance of medicinal plants to human life is infinite including fundamental contributions to health care system. India is blessed with rich and diverse heritage of cultural traditions, which are associated with the use of wild plants as medicines. West Bengal is a small but thickly populated province in the eastern part of India. In its south western part, the province has the red and lateritic zone constituting 28% of its total geographical area. Jhargram is situated in this part, which is a tribal based district. According to SenUday and Bhakat (2021), there are 44 genera belonging to15 families of pteridophytes are available

in Jhargram district of West Bengal. The main tribes are Santal, Lodha, Munda, Kheria, Sabar, Bhumis and Kurmi belonging to Pre-Dravidian racial stocks, who mainly reside in close association with the forest areas of the district. Earlier Lodha, Kheria and Sabars were mostly migratory in nature, but the present-day socio-economic structure has compelled them to settle permanently and partially associated themselves with agriculture. Each ethnic community has their own health care system and ancient knowledge, sometimes referred to as ethno-therapeutics. Such knowledge is passed on from generation to generation without any written records and the traditional medicinemen, who practices this system are known as 'Ojha'. Over the years, such ethno-therapeutics has proved to be an invaluable treasure in drug screening programme. The present study is focused on the indigenous knowledge and practices of pteridophytic flora as medicine by the ethnic people of Jhargram district.

Study Area

The study was done in Jhargram District of West Bengal, India, which has an area of 3,037.64 sq. km. The district belongs to 21°87/ to 22o35/ N longitude and 86° 33/ to 87° 90/ E latitude. There are total eight blocks in this district and the study was done in different villages covering all the blocks.

Material and Methods

Extensive field survey was undertaken for documenting information of most of the pteridophytes, which are used as a medicine by the ethnic people of this region. Survey was conducted in different villages covering all the eight blocks of Jhargram District. The traditional medicine men of the area, locally known as 'Ojha', who also perform some magico-religious practices to supplement their prescriptions were selected as the primary source of information regarding the use of such plants. The collected information was cross-verified by interviewing other Ojhas to confirm their authenticity. The secondary sources of information were included the rural ethnic people, particularly the elderly knowledgeable ones. Additional information's were obtained using questionnaire to the village people. The questionnaire allowed descriptive responses on the plant prescribed, such as use parts, ethnomedicinal uses, detailed information about mode of preparation (i.e. decoction, powder, paste and juice), form of use either fresh or dried and method of application. Plant specimens were collected from the local forest areas and then dried for the preparation of herbarium specimens.

Result and Discussion-

The present study reveals that 12 species under 6 families are generally used as medicine by different tribes of Jhargram district. Among them four species are from Lygodiaceae, three from Pteridaceae, two from Marsiliaceae and one species each from four families namely Dryopteridaceae, Polypodiaceae and Selaginellaceae. In most of the cases whole plants or leaf, sometimes root or rhizomes are used in ethnomedicine. All these species are enumerated here with their botanical names, followed by family name, vernacular name, sporulation, occurrence and ethno-medicinal uses.

1. *Adiantum caudatum* L.

- Family – Lygodiaceae.
- Vernacular Name –Mayurshikha.
- Sporulation –December to February.
- Occurrence – Rock crevices, basic rocks in damp positions.

Ethnomedicinal Uses –

i. Powder of the whole plant is taken orally for gastro intestinal (GI) disorders, such as jaundice, diarrhoea and abdominal pain. The leaves are also effective for dissolving the kidney calculi and as a diuretic agent to stimulate urine production after oral administration.

ii. Leaf of this plant is used to stop excess bleeding after child birth. Half cup of juice is extracted by smashing of fresh leaf and it is given to mother thrice a day for 2-3 days for the same. It also helps in child birth.

iii. Oral application of the frond decoction is useful for clearing respiratory system, cough, bronchitis, dyspnoea, asthma and chest infections. The fronds are used against fever, migraine and also applied externally to treat skin diseases.

iv. Fresh or dried leaves are grind to make paste or power. 50 gm of this paste or power is mixed in 200 ml coconut oil and applied on scalp to check hair fall.

List of Ethnomedicinally used Pteridophytes

SL. NO	Scientific Name	Vernacular / Common Name	Family	Use Parts	Sporulation Time
1	***Adiantum caudatum* L.**	Mayurshikha	Lygodiaceae	Whole plant, mainly leaf.	December to February
2	***Adiantum capillus-veneris* Linn.**	Biddapata	Lygodiaceae	Leaf	„
3	***Adiantum lunulatum* Burm. f.**	Goyaliyalata, Kalijaant	Lygodiaceae	Root and leaf	„
4	***Cheilanthes tenuifolia* (Burm. f.) sw.**	Dalamkhundruj	Pteridaceae	Leaf and root	May to August
5	***Dryopteris filix-mas* (L.) Schott.**	Male Fern	Dryopteridaceae	Root and leaf	November to February
6	***Lygodium flexuosum* (Linn.) Sw.**	Rudra Jata.	Lygodiaceae	Root and Rhizome	September to December
7	***Masilea minuta* L.**	Susnisak	Marsiliaceae	Whole plant, specially leaf.	November to March.
8	***Masilea quadrifolia* Linn.**	Susnisak	Marsiliaceae	Leaf or whole plant.	November to February.
9	***Polypodium vulgare* L.**	Golden Maiden Hair Fern	Polypodiaceae	Rhizome	July to October.
10	***Pteris multifida* Poiret ex Lamarck.**	Spider Brake	Pteridaceae	Whole plant	November to February
11	***Pteris vittata* L.**	Ladder Brake	Pteridaceae	Whole plant, specially root.	November to February
12	***Selaginella semicordata* (Wall.Ex Hook. &Grev.) Spring.**	Sanjeevani / Mrita-Sanjeevani.	Selaginellaceae	Whole plant, specially leaf.	October to January

2. *Adiantum capillus-veneris* Linn.

- Family – Lygodiaceae.
- Vernacular Name – Biddapata.
- Sporulation –December to February.
- Occurrence – Moist, shady places.

Ethnomedicinal Use –

i. Syrup is made from leaf for the treatment of cough, bronchitis and throat afflictions. This is supported by Sing and Upadhyay (2012). Leaf is used as a detoxificant in alcoholism and to expel worms from the body. Externally leaf paste is applied as a poultice on snake bite, bee stings, etc. Leaves are also used as a tonic, stimulant, purgative, demulcent and emollient.

ii. A paste is made from the fronds is applied to the forehead to relieve headaches and also applied in the chest to relieve chest pain. The plant is best used fresh, though it can also be harvested in the summer and air dried for later use.

iii. The leaves are used as a hair tonic and treatment for dandruff. This is supported by Ibn Sina – 2005

and Aghili—1992, it is a potent hair tonic that treats alopecia and helps hair growth and it is useful for dandruffs.

iv. According to Aghili (1992) the powder of whole plant were extensively administered for gastrointestinal disorders such as jaundice, diarrhoea and abdominal disorders It is also effective for dissolving the kidney calculi and as a diuretic agent in oral administration(Ibn Sina - 2005 and Aghili—1992).

v. Fronds are also introduced as a powerful anti-inflammatory agent. Therefore, it is apply on fistula in the form of ointment.

vi. The plant also helps child birth and extracting placenta with oral administration of decoction.

3. *Adiantum lunulatum* Burm. f.

- Family – Lygodiaceae.
- Vernacular Name – Goyaliyalata, Kalijaant.
- Sporulation –December to February.
- Occurrence – Generally grow in old brick walls.

Ethnomedicinal Use

i. The decoction of leaf is useful in dysentery, indigestion, diseases of the blood, ulcers and erysipelas. The leaf paste is used in leprosy. The leaf paste mix with coconut oil and applied 3-4 times daily. The leaf paste is applied over the area affected with herpes and wounds. The paste is also applied over the area bitten with scorpion, spider bite or any other insect bite. The fresh juice is given in a dose of 20 – 25 ml to nullify the effect of poison.

ii. The tribal people of this district used the leaf extract for the treatment of cough, asthma and bronchitis. The plant is considered to be a bronchodilator, diuretic and pectoral.

iii. The root stock is considered good for treating fever and elephantiasis; especially it is used in child fever. The decoction of root is also used throat infections.

iv. Leaf is also used to overcome hair falling by putting paste of its leaves on head for an hour or so before taking bath for a fortnight.

v. In Gidhni Block the tribal people uses this plant for urinary diseases. The leaf extract is taken orally and the leaf paste is applied on the lower portion of stomach, for clear and early release of urine

vi. Leaf is used for the treatment of diarrhoea. The leaf powder is used with milk to treat diarrhoea in a dose of 3 – 5 gm daily for three times. The leaf powder is given with honey in a dose of 3- 5 gm to treat cough, hoarseness of voice and rhinitis.

vii. To treat difficulty in urination, the cold infusion is given in a dose of 40 -50 ml of leaf extract for three times daily.

viii. Juice of the fresh plant is applied to abscess and wounds for quick healing. Fresh juice of the fronds is used for the treatment of dysentery, ulcer and burning sensation.

ix. The whole plant is applied externally in burning area. Fronds burnt with oil, used as an application for itch. It is also used in abscess, blood disorders, skin disorders, bleeding disorders such as menorrhagia, nasal bleeding etc. The leaf extract is put in drops into the nose, to stop bleeding, during summer season.

4. *Cheilanthes tenuifolia* (Burm. f.) sw.

- Family- Pteridaceae.
- Vernacular Name- Dalamkhundruj.
- Sporulation – May to August.
- Occurrence – Rock dwelling fern.

Ethnomedicinal Uses—

i) Fronds paste is applied on abscess in the form of poultice to liberate pus (Abscess) and also used as antiseptic. The poultice is given once a day till the abscess is cured.

ii) The decoctions of leaves are traditionally used as a hair tonic. The ashes of its burnt leaves mixed with those of other plants like *Biophytum* sp., *Hedyotis* sp. and a wild pepper are powdered over newborn infants. Some tribal people traditionally use the decoction of whole plant as a hair tonic.

5. *Dryopteris filixmus* (L.) Schott.

- Family – Dryopteridaceae.
- Common Name – Male Fern.
- Sporulation – November to February.
- Occurrence – Favourably occurs in damp and shady places.

Ethnomedicinal Uses

i) Ethno-medicinally the leaf of this fern is most popular and effective against tape worms. According to Duke (2002), it is used for the treatment of worm infections and it is especially toxic to tape worm. The root is

harvested in autumn and can be dried for later use. The methanol extract of the leaves has been found to possess potent antioxidant and cytotoxic activities, it also significantly used in treating diarrhoea (Ali *et. al*. 2012). It has been found to have antimicrobial activities (Mandal and Mondal,2011; Soare *et. al*. 2012).

ii) The root is taken in the treatment of internal haemorrhage, uterine bleeding, mumps and feverish illnesses. The root is very much toxic, so determination of the dosage of application is very much important. It must be done with much caution and by a qualified practitioner. Pregnant women and people with heart complaints should not be prescribed this plant. The root is used externally as a poultice in the treatment of abscesses, boils, carbuncles and sores.

6. *Lygodium flexuosum* (Linn.) Sw.

- Family – Lygodiaceae.
- Vernacular Name- Rudra Jata.
- Sporulation – September to December.
- Occurrence – Common in shady and moist waste places.

Ethnomedicinal Use

i) Fresh root are boiled with mustard oil and used in external applications for rheumatism, sprains, scabies, eczema and cut wounds by the Lodha tribes. They also reported this is particularly useful for carbuncles, which is supported by Banerjee and Sen -1980, Chopra & Nayar -2006, Kamble *et. al.* -2010.

ii) The rhizome and root is ethno-medicinally useful in the treatment of jaundice by the Kheria, Sabar and different tribes of Jhargram District. Similar application has also been reported by Yadav *et.al*. (2012), according to them the leaf paste is applied all over the body for 7 days to cure jaundice by the Kadar tribes of South Western Ghats of India and some other tribes like Rabha, Oraon, Mech tribes of Jalpaiguri district of West Bengal, used the rhizome and root paste in jaundice.

iii) The ash of the plant is used for treating herpes, this plant is used to feed domestic animals to treat foot and mouth diseases.

iii) Rhizome of this fern is widely used in treating various ailments like jaundice, dysmenorrhoea, wound healing and eczema Sahoo (2017).

iv)Root is used to reduce inflammation and acts as panacea for wounds treat ulcer. Root is also used in various respiratory diseases, general disorder, rheumatism, muscles sprains and it also had the potential to act as the pain killer.

v) The root paste is applied externally on sores of cattle. Paste of the frond is externally applied in insect bite. According to Samant & Pant- 2006, Dangol-2008, this plant is used to feed domestic animals to treat foot and mouth diseases.

vi) This fern reported to exhibit antifertility activity. So the alcoholic extract of it is used by a tribal population in Maharastra showed antifertility activity in rats, mice and rabbits (Gaitonde and Mahajan -1980).

7. *Marsilea minuta* L.

- Family – Marsiliaceae.
- Vernacular Name – Susnisak.
- Sporulation – November to March.
- Occurrence – Favourably occurs in marshy land or near the bank of ponds.

Ethnomedicinal Use

i) The plant is widely used in different traditional and folk medicinal systems for its medicinal value and recommended for the treatment of psychopathy, diarrhoea, respiratory diseases and skin disease. It is prescribed by folk medical practitioners to treat diabetes and gastrointestinal disorders.

ii) The tribal people cooked the leaves in mustard oil with salt, chilli and garlic. They consume regularly to relief hypertension, sleep disorder and headache.

iii) Fresh shoot juice is used to remedy of cough, respiratory troubles, especially of the babies.

iv) The whole plant including root is made into paste with whole plant of *Centella asiatica* applied twice daily for seven days around the nipple to improve lactation after child birth (Shahidullah *et. al.* 2009).

v) The whole plant is extensively used in the treatment of cough and respiratory troubles. This is supported by Sen *et. al*.(2011) and Upreti *et.al.*(2009). The whole plant crushed with sugar candy or honey and used to cure infant diarrhoea (Sen and Behera, 2008).

vi) The leaf juice is used to stop nose bleeding and indigestion. The leaves are rolled in a leaf of *Shorea robusta*, both the leaves are then boiled and then applied to swollen gums in order to reduce the swelling.

vii) The leaf extract reduces cholesterol and triglyceride levels in blood and liver substantially. The extract of whole plant is taken to increase the fertility.

8. *Marsilea quadrifolia* Linn.

- Family – Marsiliaceae.
- Vernacular Name – Susnisak.
- Sporulation – November to February.
- Occurrence – It occurs in open moist ground or in marshy lands.

Ethnomedicinal Uses

i) As a folk medicine it is known to be a memory enhancer also enabling to help the learning behaviour. Some even claim about its antidiabetic role.
ii) The leaves are popular vegetables and all are consumed as food. Besides this the plant or its extract are used in folk medicine as anti-inflamatory, depurative, febrifuge and refrigerant.
iii) It has nerve relaxant nature and curative properties for various other ailments of nervous system and its nutritional values.
iv) The leaf juice is used as diuretic and febrifuge. The plant is also applied externally in the treatment of snake bites and skin disease, including abscesses.
v) The leaves are warmed in 50 ml mustard oil with 3 – 5 gm garlic, then poured over washed and chopped in to 250gms. It consumed only in the evening for sound tension free night sleep and relaxes them both physically and mentally. According to Soni and Singh (2012) some tribal people cooked the whole leaf with 4–5 gm. desi masala (mixture of red chillies, turmeric, coriander and cumin) and salt. They consumed it for hypertension and other nerve disorders, all type of body aches, insomnia.
vi) 10 gm of entire fresh plant paste is mixed with 100 gm of card, then take it to cure epilepsy. The dosage is given orally once a day in empty stomach for one month (Soni and Singh, 2012).

9. *Polypodium vulgare* L.

- Family – Polypodiaceae.
- Vernacular Name – Golden Maiden Hair Fern.
- Sporulation – July to October.
- Occurrence – Grow in moist shady places.

Ethnomedicinal Uses—

i) The rhizome is used to stimulate bile production and it is regarded to have expectorant, diuretic and mild laxative properties. Due to its expectorant properties it is used as an antispasmodic agent to cure dry cough, bronchitis and other infections of the respiratory system. For the treatment of the disease one or two table spoons of the dried root or 20 cm. of fresh rhizome boiled in 100 ml water and allow to steep for 15 minutes. The recipe can be divided into 3-4 daily doses.
ii) Leaf is useful as a natural treatment for disease like jaundice and hepatitis. It is also helpful as a remedy for indigestion and lack of appetite.
iii) The rhizome is considered a safe remedy to use as a treatment for constipation in children and also used to treat intestinal parasites, especially tape worms. It is prepare as, 20 cm of fresh rhizome boiled in 200 ml water for 5 minutes and soak for 3 hours before staining. Then divided the brew into 3-4 daily doses.
iv) The fresh or dried rhizomes are crushed in to powdered form and externally on minor cuts, scrapes and wounds to speed up healing and reduce the inflammation. The rhizome has antiepileptic activity, so it is effective in cracks of interphalyngeal spaces, claw hand, tumours and rheumatic pain on external application. It is also used in powder form as snuff in polypus of nose.

10. *Pteris multifida* Poiret ex Lamarck.

- Family – Pteridaceae.
- Common Name – Spider Brake or Wall Brake.
- Sporulation – November to February
- Occurrence – Often grow in cracks of older walls.

Ethnomedicinal Uses—

i) The whole plant is used for the treatment of diarrhoea and dysentery. Plant is also used for improvement of rich food metabolism.
ii) It has various bioactive flavonoids with heat-clearing, antipyretic, detoxification, antibiotic, anti-inflammatory and antimutagenic activity (Lee and Lin, 1988).
iii) The fronds made into paste, are applied to chronic gouty and other swelling, also for chronic tumours.

Adiantum caudatum L**.**

Adiantum capillus-veneris Linn

Adiantum lunulatum Burm.f.

Cheilanthes tenuifolia (Burm.f) Sw.

Dryopteris filixmas (L.) Schoot.

Lygodium flexuosum (Linn.) Sw.

Masilea minuta L.

Marsilea quadrifolia Linn.

Polypodium vulgare L.

Pteris multifida Poiret ex . Lamarck.

Pteris vittata L.

Selaginella semicordata (Wall.Ex Hook. & Grev.)Spring.

11. *Pteris vittata* L.

- Family – Pteridaceae.
- Common Name –Ladder Brake or Chinese brake or Chinese ladder brake.
- Sporulation – November to February.
- Occurrence – Generally grow in concrete structure and cracks of buildings.

Ethnomedicinal Uses—

i) It is used in diarrhoea, dysentery, stranguria with turbid urine, leucorrhoea, jaundice, furuncle, swelling, parotitis, mastitis, fever and convulsions. In diarrhoea and dysentery 10 – 15 gm of whole plant decoction are taken orally for three times daily.

iii) The root is used in snake bites, insect bites, non-traumatic haemorrhage or traumatic haemorrhage.

iv) The whole plant of both *P. vittata* and *Hedyotis diffusa* are mixed properly in equal amount and made into paste, then used in urinary troubles.

12. *Selaginella semicordata* (Wall. Ex Hook. & Grev.) Spring.

- Family- Selaginellaceae.
- Vernacular Name- Sanjeevani / Mrita-Sanjeevani.
- Trade Name -- Sanjeevani Booti, Lakshan Booti or Pathar Chatta.
- Sporulation –October to January.
- Occurrence – Generally grow in marshy, shady places.

Ethnomedicinal Uses— The herb is extensively exploited in very large scale and sold brought in various markets of this district under different trade names, for their medicinal value.

i) The whole plant is used in menstruation, uterine bleeding, urinary tract infections and post labour tonic. Dried whole plants were dipped into water overnight, and then in the next morning the tribal people take the water in empty stomach for heart disorders, stroke, respiratory infections and as tonic stimulant. So, locally it is known as Mrita-Sanjeevani.

ii) The leaf paste is used in wounds, injury, broken bones and rheumatism, tonic stimulant for body fitness, high fever and also ashes to rub back pain.

iii) Young leaves are eaten as depurative or stomachic. The decoction of leaves are used as protective after child birth and used in treating skin disease such as itches and ring worm.

Conclusion

Some traditional herbal medicines are prepared from different species of pteridophytes, which are available in their surrounding forest and natural habitat for treatment of some common diseases in Jhargram district of West Bengal. The traditional knowledge of this medicinal application is passed on from generation to generation without any written records. So, this traditional knowledge is being lost due to lack of awareness and deforestation. As a result, the valuable medicinal pteridophytes are becoming rare and the medicinal information is being lost. So, there is an urgent need to protect and conserve this pteridophytes. Active participation of local people is necessary to protect it and for sustainable management of this resource.

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Heavy metal contamination in waterbird feathers from Porbandar, Gujarat, India

Dhavalkumar Varagiya [1,2,*], Bharat Jethva [3] & Devang Pandya [1]

[1] School of Pharmacy, RK University, Bhavnagar Highway, Kasturbadham, Rajkot, Gujarat, India. PIN 360020
[2] Center for Sustainable Conservation Action and Protection of Ecosystems of the Seas, India (C-SCAPES), Tata Chemicals Society for Rural Development, C/o Tata Chemicals Limited, Mithapur, Dwarka, Gujarat, India PIN 361345
[3] Green Support Services, Sargasan Circle, Gandhinagar, Gujarat, India PIN 382421
[*] Corresponding author dhaval.mwcc@gmail.com

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Abstract

Heavy metal in waterbirds has been the focus of many publications over the last few decades and their feather concentration is an important and non-destructive bioindicator of heavy metal concentration. Kite-flying festival is celebrated on 14th January every year in Porbandar when many birds are injured in polished kite flying threads. The birds that did not survive the injury were included in the study with prior permission from the forest department. Feathers of 28 individuals of 12 different waterbird species were collected from the breast, tail, primaries, and secondaries and later sealed for analysis. Copper, zinc, iron, chromium, lead, and cadmium were analyzed by an inductive coupled plasma-mass spectrometer (ICP-MS). In this study, Cadmium levels were below the detection limit in all 28 samples. A Red-naped Ibis (*Pseudibis papillosa*), rescued from the Vadi Plot region of Porbandar possessed the highest metal concentration of iron (1937.64 ppm) and zinc (412.29 ppm). The highest concentration of lead was 4.56 ppm in a Black-headed Gull (*Chroicocephalus ridibundus*), from Subhashnagar. Lesser Flamingo (*Phoeniconaias minor*), had highest copper concentration (18.32 ppm). Indian Pond Heron (*Ardeola grayii*), had the highest concentration of Chromium (2.16 ppm)

Keywords: Copper; zinc; iron; chromium; lead; waterbirds; waders; heavy metal; toxicity; Porbandar, Gujarat

Introduction

Paracelsus in the basics of toxicology says "The dose makes the poison" (Anon 2011). The extraction of metal ores and refinement of metals are two of the

most important anthropogenic sources of metals in the environment and metals can pollute the environment as they are used in industrial processes. Several metals are designated as priority contaminants, which are chemical substances that are monitored and assessed, some of which include antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, platinum, thallium, and zinc (Sparling 2016).

Despite a large sampling challenge and economic cost for analysis, the world literature on heavy metal concentrations in birds has grown considerably over the last few decades (Amiard-Triquet et al. 1991; (Beyer et al. 2005; (Ancora et al. 2008; (Bichet et al. 2013; (García-Fernández 2014; (Ashkoo et al. 2020; (Biswas et al. 2020). Many waterbirds are now considered vulnerable or endangered by different countries, restricting the chemical analysis to non-invasive methods using feathers and eggs-shells (Eisler 1987).

Feathers can be a remarkable bio indicators for heavy metal contamination as these can be sampled non-invasively, are simple to obtain, do not require special storage conditions like internal organs, and are resilient because birds sequester non-essential metals in their feathers (Kushlan 1993). The feather contamination is also proportional to the body mass of the bird, which may grow with age and feathers represent the local contamination of a specific environment of certain metals like lead (Alipour et al. 2016). Non-essential salts along with the heavy metals are secreted by the uropygial gland of the seabirds, who smear it on their feathers while preening, reinforcing the impact of metal contamination onto the feather (Dmowski 2000). It was further shown in a recent analysis with the common magpie (*Pica pica*), that external contamination with heavy metals is most likely caused by preening. This suggests that the contaminants of certain heavy metals on the feathers are also coming from an internal source, which is being produced by the bird itself (Jaspers et al. 2009).

The feathers as a bio indicator for external and internal contaminations have been used widely in many Asian countries like Pakistan (Movalli 2000; (Malik and Zeb 2009; (Nighat 2013; (Ullah et al. 2014); China (Zhang et al. 2006; (Fu et al. 2014; (Kwok et al. 2014); Indonesia (Burger and Gochfeld 1997); and India (Muralidharan et al. 2004; (Jayakumar and Muralidharan 2011; (Savita 2014; (Kushwaha 2016; (Biswas et al. 2020; (Pandiyan et al. 2020). To our knowledge, there are no data available on heavy metals in waterbirds from Gujarat state, India. We had the opportunity to investigate levels of heavy metals in the feathers of waterbirds collected from urban and rural wetlands of the Porbandar district of Gujarat state. In addition to non-essential heavy metals, it was felt appropriate to analyse essential elements of priority concern like Copper and Zinc (Plessl et al. 2017).

Materials and methods

Study area

Porbandar (21° 37' 48"N, 69° 36' 00"E) is an administrative district in the western part of the Gujarat state, with Porbandar town as the headquarter. Former Junagadh was divided into two districts, one of which was Porbandar. The district occupies an area of 2298 sq km. There are a total of 226 wetlands, including 95 small wetlands (less than 2.25 ha) with a total wetland area of 22199 ha. Inland wetlands account for 27.3 % of the total wetland area, while coastal wetlands account for 72.7 % of the total wetland area. The district's major wetland types are lagoons, rivers/streams, reservoirs, and sand/beach (Gujarat_Wetland_Atlas 2010).

Porbandar is known as "Surkhaabi Nagri" (in the Gujarati language) which translates to "Urban Flamingo City." Flamingos congregate in large numbers in certain wetland areas, such as "Chhaya Rann" and "Javar." However, the entire Porbandar district should be recognized for its various wetlands and numerous waterbirds, in addition to flamingos. Despite the district's many important wetlands, it currently has only one wetland-based sanctuary (the Porbandar Bird Sanctuary), which is situated in the heart of the headquarter and has a very small area of 9.33 ha. Due to its limited area, it is certainly inadequate to accommodate the thousands of waterbirds that winter in the district. In such a scenario, a substantial number of other wetlands, including their "unprotected" status, help to preserve the district's avian ecological balance (Vargiya et al. 2015).

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Sample collection and analysis

Permission was obtained from Gujarat Forest Department prior to sampling. On 14th January 2021, many birds got entangled in kite flying threads polished with powdered glass making the injury more severe. Such injured birds were rescued by various NGOs

Fig. 1. A veterinary doctor collecting the sample from a dead specimen of Painted Stork.

as well as individuals and proper veterinary aid was provided to the rescued birds by the veterinary doctor (Personal observation of authors). The birds which did not survive the injury were included in the study.

Mixed feathers from the breast, tail, primaries, and secondaries were gathered and sealed. Number varies for each species which is mentioned in Table 1 The mixed feathers were cut into small pieces to make 1000 mg. each and labelled properly. If the process of removing dust and washing the feathers takes a long time, the heavy metals in the feathers can be removed (Dmowski 1999). Hence, feathers were not washed as heavy metals of both exogenous and endogenous origin were the focus of our study. The samples were kept dry and analysed at Gujarat Laboratory in Ahmedabad, Gujarat. Copper (Cu), zinc (Zn), iron (Fe), chromium (Cr), lead (Pb), and cadmium (Cd) were analysed by an inductive coupled plasma-mass spectrometer (ICP-MS), Agilent Technologies, Japan. The standards for all elements to be detected were procured from the National Institute of Standard Technologies, US. The quantification limit was set to 0.05 ppm.

A sample of 500 mg was applied to a microwave digestion system, Anton-Paar, Germany. Once the digestion system was completed, the digested solution was diluted by distilled water up to 25 ml to make a test solution. The test solution was transferred to the sample introduction system of the ICP-MS instrument and nebulized, and the aerosol was transferred to a high frequency inductively coupled argon plasma. Calculation of the concentration (in ppm) was done automatically by the Mass Hunter software of the ICP-MS (Gujarat_Laboratory 2021).

A two-tailed unpaired t-test (CI 95) was performed for the groups of resident and migratory species for all detected heavy metals viz, zinc, iron, copper chromium, and Lead. The null hypothesis was that there is no statistically significant difference between contamination loads among the groups for resident or migratory bird species.

Results and Discussion

The mixed feathers of 28 individuals of 12 different waterbird species viz, Black-headed Gull (*Chroicocephalus ridibundus*), Black-headed Ibis (*Threskiornis melanocephalus*), Cattle Egret (*Bubulcus*

Fig. 2. Study area with traceable rescue locations and bird treatment camp

ibis), Common Crane (*Grus grus*), Demoiselle Crane (*Anthropoides virgo*), Pacific Golden Plover (*Pluvialis fulva*), Great Egret (*Ardea alba*), Heuglin's Gull (*Larus fuscus heuglini*), Lesser Flamingo (*Phoeniconaias minor*), Painted Stork (*Mycteria leucocephala*), Indian Pond Heron (*Ardeola grayii*), and Red-naped Ibis (*Pseudibis papillosa*) were collected from Porbandar, Gujarat. Out of these 12 species, three species viz, Black-headed Ibis, Lesser Flamingo, and Painted Stork are Neat Threatened and the rest are Least Concerned as per IUCN red list category (IUCN 2021). All 28 samples were analysed and data are summarised in Table 1 and illustrated in Figure 2. Cadmium level was below the detection limit (0.05 ppm) in all the samples. The pattern of metal concentrations in feathers was as follows: Fe > Zn > Cu > Pb > Cr.

Here, we discuss the heavy metal contamination level found in the present study and compare with that reported in other Asian countries.

Zinc (Zn): Zinc is an essential element and the threshold dose for wild species is not established. The lowest concentration of zinc was detected in Lesser Flamingo (19.97 ppm) while the highest was in Red-naped Ibis (412.29 ppm). Zinc's avian threshold lethal dose of 1200 ppm is known for captive Mallard (Gasaway and Buss 1972). Zinc concentration in Cattle Egret in the current study (59.96 ppm) is lower than reported from Chenab River (133.8 ppm), Rawal Lake (138.4 ppm), Ravi River (155.2 ppm) of Pakistan (Malik and Zeb 2009); Sialkot (219.9 ppm), and Lahore (529.9 ppm) areas of Pakistan (Abdullah et al. 2015) as well as Nilgiri (182.42 ppm), India (Muralidharan et al. 2004). But, it is higher than reported from Taunsa (1.8 ppm) (Boncompagni et al. 2003), Mailsi (10.67 ppm), Trimun Headworks (18.53 ppm), and Shorkot (18.83 ppm) of Pakistan (Ullah et al. 2014). Zinc contamination of respective species in the current study is lower than the reported mean value for Common Crane (92.56 ppm), Demoiselle Crane (150.53 ppm), and Great Egret (94.12 ppm) from Sheyang, China (Fu et al. 2014); but, higher than the reported mean value for Painted Stork from Point Calimere Wildlife Sanctuary,

Table 1. Mean ± Standard deviation values (ppm) of five detected heavy metals among waterbirds

No	Species	n	Weight (gm)	Zinc (Zn)	Iron (Fe)	Lead (Pb)	Copper (Cu)	Chromium (Cr)
1	Black-headed Gull	3	284	76.67±21.02	315.97±239.23	2.89±1.51	4.85±2.62	0.75±0.39
2	Black-headed Ibis	2	975	51.03±11.52	274.85±223.87	2.64±0.60	6.47±0.55	0.62±0.31
3	Cattle Egret	2	365	59.96±22.47	192.05±152.58	0.88±0.77	3.93±0.34	0.49±0.35
4	Common Crane	3	5500	45.85±7.38	333.34±46.33	1.41±0.50	3.69±0.50	0.68±0.04
5	Demoiselle Crane	7	2417	65.37±13.57	262.51±109.58	0.99±0.33	3.79±0.98	0.67±0.50
6	Pacific Golden Plover	1	135	76.12	519.85	1.34	4.18	0.71
7	Great Egret	2	873	53.98±2.12	75.6±45.2	1.51±1.3	3.3±0.74	0.22±0.04
8	Heuglin's Gull	1	715	64.88	177.91	1.19	5.19	0.46
9	Lesser Flamingo	4	1500	73.04±58.67	544.54±188.96	1.27±0.28	8.67±7.22	0.69±0.16
10	Painted Stork	1	3180	35.36	374.23	1.69	3.07	0.73
11	Indian Pond Heron	1	253	55.58	1376.13	2.26	3.37	2.16
12	Red-naped Ibis	1	822	412.29	1937.64	1.89	12.3	0.89

Weight: average body masses from (Dunning Jr 2007) except Ibises which are averaged from five individuals of respective species rescued around Ahmedabad, Gujarat.

(1.5 ppm) India and Pichavaram, Tamilnadu, (1.6 ppm) India (Pandiyan et al. 2020).

Iron (Fe): Ideal levels vary as per the feeding guilds of the species. The lowest concentration of iron was found in Great Egret (43.61 ppm) and the highest was in Red-naped Ibis (1937.64 ppm), the same individual also had the highest zinc contamination. Iron concentration in Cattle Egret in the current study (192.05 ppm) is in the same range as those reported from Chenab (181.8 ppm), Pakistan (Malik and Zeb 2009), Trimun Headworks (200.56 ppm), Pakistan (Ullah et al. 2014); but, lower than reported from Sialkot (338.5 ppm), Pakistan (Abdullah et al. 2015); and higher than reported from Mailsi, Shorkot (Ullah et al. 2014), Rawal Lake, Ravi River (Malik and Zeb 2009), and Lahore (Abdullah et al. 2015) of Pakistan. The iron concentration of seven species in this study viz, Black-headed Ibis, Lesser Flamingo, Golden Plover, Black-headed Gull, Lesser Flamingo, Pond Heron, and Red-naped Ibis is the highest among the Asian countries reported so far.

Copper (Cu): The lowest concentration of copper was found in Black-headed Gull (2.6 ppm) rescued from Bokhira and the highest was in Lesser Flamingo (18.32 ppm). Copper concentration in Cattle Egret in the current study (3.93 ppm) is in the same range as those reported from Chenab, Rawal, and Ravi river of Pakistan (Malik and Zeb 2009); but, lower than reported from Nilgiri (219.93 ppm), India (Muralidharan et al. 2004), Sialkot (59.8 ppm), and Lahore (52.8 ppm) of Pakistan (Abdullah et al. 2015); and higher than reported from Mailsi, Trimun Headworks, and Shorkot, of Pakistan (Ullah et al. 2014).

Lead (Pb): The lowest contamination of lead was found in Cattle Egret (0.34 ppm) and the highest was in Black-headed Gull (4.56 ppm). Only one out of 28 individuals had a higher than a threshold level of lead. The contamination of 4 ppm of lead in the feathers has been identified as a threshold level for adverse effects that cause sub-lethal and adverse reproductive effects (Solgi et al. 2020). It has been also associated with delayed parental and sibling recognition, impaired thermoregulation, locomotion, depth perception, feeding behavior, and lowered chick survival in gulls (Kim and Oh 2012). Black-headed Gull with the highest lead contamination under the current study was already dead when rescued from Subhashnagar, an industrial area of Porbandar city. Higher than the threshold level of lead feather contamination has been already reported in Cattle Egret from eight areas of Pakistan (Malik and Zeb 2009; (Ullah et al. 2014; (Abdullah et al. 2015) and Nilgiri, India (Muralidharan et al. 2004); in Common Crane, Demoiselle Crane, and Great Egret from Sheyang, China (Fu et al. 2014); and in Painted

Stork from Pichavaram, Tamilnadu, India (Pandiyan et al. 2020). Adult Common Terns (*Sterna hirundo*) had lower lead contamination in their feathers from 5.8 ppm in 1978 to 1.0 ppm in 1985, remained unchanged until 1988, and then rose to 3.0 ppm through 1992. "Lead declines in feathers coincided with environmental decreases in lead from the gradual elimination of leaded gasoline in vehicles" (Eister 2009). As previous research on Common Tern suggests that feather lead concentrations are more likely a result of external contamination than an internal excretion during feather development, and using feathers as an indicator of lead contamination actually measure its external deposition (Scheuhammer 1987).

Chromium (Cr): The lowest contamination of chromium was found in Great Egret (0.19 ppm) and the highest was in Indian Pond Heron (2.16 ppm). Indian Pond Herons are seen feeding among the dump yards of solid waste. Colored and contaminated water and solid waste itself are the responsible factor behind unnatural pigmentation in the feathers. Such pigmented feathers may contain heavy metals. This Indian Pond Heron had unnatural pigmentation in the plumage probably due to feeding habits around the areas with solid waste dumping. The contamination of 2.8 ppm of chromium in feathers has been identified as avian threshold dose (Abdullah et al. 2015). The studied avian populations in the Porbandar district are not at risk of chromium toxicity as of now unlike eight sites of Pakistan having very higher than threshold dose of chromium in Cattle Egret feathers (Malik and Zeb 2009; (Ullah et al. 2014; (Abdullah et al. 2015); Sheyang, China were higher than threshold contamination has been reported in the feathers of Common Crane, Demoiselle Crane, and Great Egret (Fu et al. 2014). Chromium concentration in Lesser Flamingo (0.69 ppm) in the current study is in the same range as those reported from Namibia (0.68 ppm), South Africa (Burger and Gochfeld 2001). Chromium does not biomagnify in aquatic food chains including birds (Eister 2009). In the area of electroplating and metal finishing industries, municipal treatment plants, tanneries, and oil drilling operations, chromium levels are high in soil, air, water, and biota (Eister 2009).

Male Great Egret with visceral gout had heavy metal contamination in the following order zinc (52.48 ppm), iron (43.61 ppm), copper (3.83 ppm), lead (2.43 ppm), and chromium (0.19 ppm). Immuno-compromised female Common Crane with fungal infection around internal organs showed below threshold level contamination viz, zinc (50.28 ppm), iron (299.14 ppm), copper (4.26 ppm), lead (1.98 ppm), and chromium (0.64 ppm). "One of the Demoiselle Crane from the flock of 25-30, dropped dead from the sky while in the flight", said the farmer who had seen the incidence. This Demoiselle Crane had below threshold level contamination viz, zinc (61.8 ppm), iron (399.63 ppm), copper (3.37 ppm), lead (1.14 ppm), and chromium (0.69 ppm).

Out of 12 species included in the present study six species viz, Black-headed Gull, Common Crane, Demoiselle Crane, Pacific Golden Plover, Heuglin's Gull, and Lesser Flamingo are migratory while other six species viz, Black-headed Ibis, Cattle Egret, Great Egret, Painted Stork, Indian Pond Heron, and Red-naped Ibis are resident of Porbandar district. For all five heavy metals, P(T<=t) two-tail was greater than 0.05 (Zn 0.49, Fe 0.32, Cu 0.84, Pb 0.44, and Cr 0.52), so the test failed to reject the null hypothesis.

Maximum number of publications of various heavy metal contamination in feathers of birds from Asian countries are for Cattle Egret. The Cattle Egret is a species that is a mostly sedentary and local resident breeder. The feather heavy metal contamination in Cattle Egret helps determine the contamination load of the surrounding (Burger and Gochfeld 1997; (Boncompagni et al. 2003; (Muralidharan et al. 2004; (Malik and Zeb 2009; (Ullah et al. 2014; (Abdullah et al. 2015). Cranes are waterbirds that serve as a link between agriculture and wetlands. Zinc, lead, copper, and chromium contaminations in Demoiselle Crane and Common Crane from Sheyang, China, are higher than Porbandar (Fu et al. 2014). Poorly digested animal feed produces high amounts of heavy metals in fertilizers made from livestock feces. Heavy metal concentrations can rise to the point that they become toxic to crops and land over time (Sparling 2016). Lesser flamingos are at the bottom of the food chain, feeding mainly on blue-green algae and small invertebrates of the shallow wetlands. However, as compared to other waterbirds, the heavy metal concentrations in Lesser Flamingo were higher. The highest copper concentration was seen in Lesser Flamingo. Lesser flamingos of Porbandar are mostly seen in urban wetlands, utilized by humans and livestock as well. Though considered essential, a higher level of copper in Lesser Flamingo indicates its presence in urban wetland soil. Such pollutants are thought to be a catalyst rather than the sole cause of avian mortality.

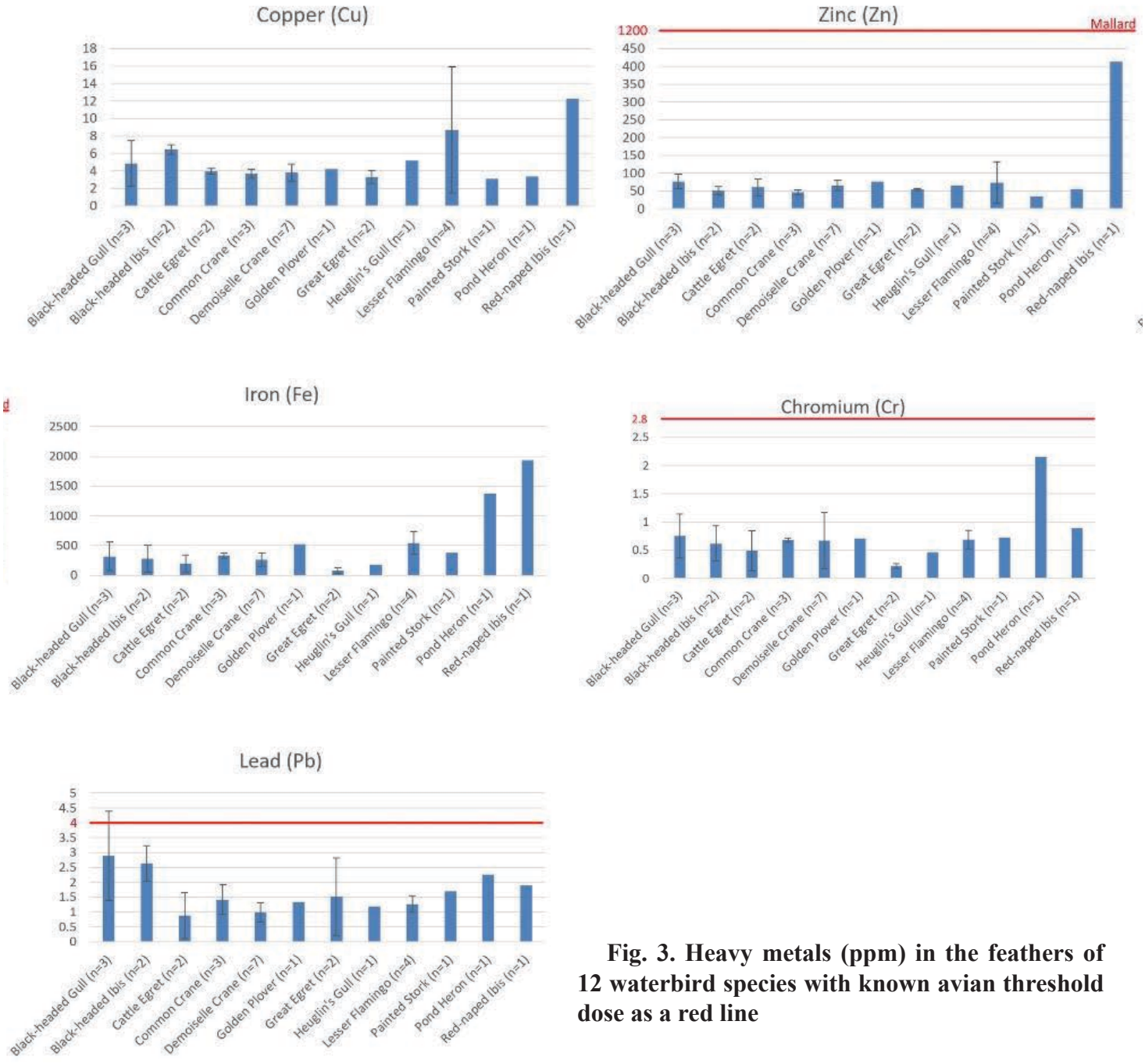

Fig. 3. Heavy metals (ppm) in the feathers of 12 waterbird species with known avian threshold dose as a red line

Heavy metal levels may not be high enough to kill the flamingos or other waterbird species on their own, but as birds pick up contaminants from the food or external contamination, they become more vulnerable to normal environmental stress, such as breeding and migration, and therefore normal behavioral habits may trigger a toxic reaction (Lovgren 2000).

Conclusion

Wetlands of the Porbandar district of Gujarat state, India are critical for migratory birds. But there is scanty evidence on pesticide or heavy metal toxicity in waterbird populations from Porbandar. Using bird feathers as a bio-indicator, we assessed the concentrations of heavy metals in Porbandar and found that the waterbirds irrespective of the feeding guilds contains heavy metals in the feathers. The iron concentration of seven

species studied in this study, namely Black-headed Ibis, Lesser Flamingo, Golden Plover, Black-headed Gull, Lesser Flamingo, Pond Heron, and Red-naped Ibis, is the highest among Asian countries so far. We also recommend repeated monitoring of heavy metal contamination studies especially around heronries using dropped and discarded feathers from chicks and adults. Feather analysis, on the other hand, is not a substitute for internal tissue analysis. But, it should be regarded as an early warning of the biota's dangerous impacts of heavy metals on waterbirds (Varagiya et al. 2021).

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Authors' contributions

Dhavalkumar Varagiya: Original Idea, Design of the study, Survey and Data collection, Laboratory Experimental work, Data analysis, Funding acquisition, and Manuscript Preparation: Bharat Jethva: Manuscript Preparation, and Supervision: Devang Pandya: Manuscript Preparation, and Supervision.

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Loktak lake (Manipur), India: Depleting bioresources and anthropogenic significance

Jogesh Laishram[1*] and Mithra Dey[2]

[1]Department of Forestry and Environmental Science, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Bishnupur District, Utlou- 795134, Manipur, India
[2]Department of Ecology and Environmental Science, Assam University, Silchar-788011, India
[1*]Corresponding author: E.mail: jogesh100.2008@rediffmail.com
Postal Address: Department of Forestry and Environmental Science, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Bishnupur District, Utlou- 795134, Manipur, India

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Abstract

The present study was conducted in five selected Loktak's lakeshore villages using household questionnaire survey. In all 300 respondents were selected from the five villages using purposive sampling technique. The study found that people residing in the five villages were dependent on Loktak lake for various bioresources like fishes, prawn, mollusks, vegetable items, fodder, fuelwood, thatch grasses, medicinal plants and raw handicrafts materials for livelihood and income. In all 34 species of fishes, 1 species of prawn, 2 species of mollusks, 9 species of vegetables, 4 species of fodders, 8 species of fuelwood, 4 species of thatch grasses, 1 species of medicinal plants and 2 species of raw handicraft were reported as decreasing bioresources from the Loktak lake. It was found that the depletion was a result of rising human dependency on the lake and other anthropogenic activities. Suitable conservation policies and protective measures for the sustainable management of the lake and its bioresources are recommended

Introduction

Wetlands are highly complex ecosystems due to interactions of diverse factors relating to land and water resources (Kabii 1996). Many parts of the world have experienced loss or degradation of wetlands on

a huge scale because of agricultural use, urbanization, excessive exploitation by local populations, and ill planned developmental activities (Kabii 1996).

Dahlberg (2005) explored competition over natural resources where fibrous plants are important to local women who produce craftwork for the growing tourist market through a case study in the Mkuze Wetlands, South Africa, Leima et al. (2008) conducted a study to analyze the socio-economic status of the people and their dependence on the park, from six villages near Keibul Lamjao National Park, Manipur and found that collection of aquatic vegetation from the park, fishing in and around the park contributed to the average annual household income. Rana et al. (2009) found that community around the Hakaluki *haor*, Bangladesh were dependent on the *haor* with a variety of livelihood activities like fishing, duck rearing, cattle rearing, fuel wood collection, sand extraction and reed collection and the *haor* was found a poverty stricken region. Singh and Moirangleima (2009) reported that the communities living around the Loktak lake depend on the lake for drinking and domestic purposes, generation of hydro-electricity power, irrigation, bio-diversity, recreation etc. and they were involved in fishing, fish farming, fish marketing, agriculture and ferrying, weaving products of the lake, etc. Turyahabwe et al. (2013) noted that contribution of wetland resources to household food security and factors influencing use of wetland resources in Uganda are characterized as insecure food. Bakala et al. (2019) also identified that wetlands in Southwestern Ethiopia offer different uses such as livestock grazing, irrigation, recreation, grass and fodder harvest, water supply for livestock and domestic uses, fish harvesting and fuel wood collection but found that they are under pressure due to human activities. Das et al. (2020) found that the majority of the people around the wetland in Mursidabad District of West Bengal (India) by engaging in agriculture or fishing activities are dependent on the wetland as their livelihoods but the health status of the wetland ecosystem was affected by higher human pressure, such as population density, growing urbanization and road density, which resulted in the degradation of wetland health.

In recent years, resources of the Loktak lake have been facing several threats due to rising human dependency on the lake, haphazard agricultural practices, pollution of water, siltation, building of Ithai dam, encroachments in the lake by constructing fishponds, construction of roads, settlements, etc. Research relating to ecology and bioresources of Loktak lake was undertaken by workers like Singh and Singh 1994; Singh 1997; Kosygin and Dhamendra 2009; Kangabam et al. 2015; Devi and Singh 2017. However, few studies were focused on the degrading status of natural resources of the Loktak lake and its impact on livelihood. Therefore, a study on the status of natural resources of the Loktak lake and its impact on the livelihood of the people living in and around the lake was conducted to understand the significance of this lake as an ecological service provider and generate awareness among the users and the concerned authorities to take up certain steps for sustainable use and conservation of the degrading natural resources of the Loktak lake. The main objective of the present study was to investigate various factors leading to depleting or degrading bioresources of the Loktak lake linked to the livelihood of the people.

Materials and Methods

Study area

Loktak Lake is located between 93°46' and 93°55' E and from 24°25' to 24°42'N in the southern part of the Imphal valley of Manipur. The oval shaped lake has a maximum length and width of 26 Km and 13 Km respectively. The depth of the lake varies between 0.5 to 4.58 m with average depth of 2.7 m (Fig. 1). Loktak lake can be considered as a sub-basin of the Manipur River basin. It has a direct catchment area of 980 sq.km and indirect catchment area of 7157 sq.km. There are 55 rural and urban settlements around the lake with a total population of 100,000 (LDA and WISA 1999). Loktak Lake is considered as the lifeline of the people of Manipur due to its importance in their socio-economic and cultural life. It is the largest natural freshwater lake in the northeastern region and plays an important role in providing ecological and economic security to the region (Trisal and Manihar 2004). A large population living in and around the lake depends upon its resources for their sustenance. The lake is rich in biodiversity and has been designated as a Wetland of International Importance under Ramsar Convention in 1990 (Trisal and Manihar 2004).

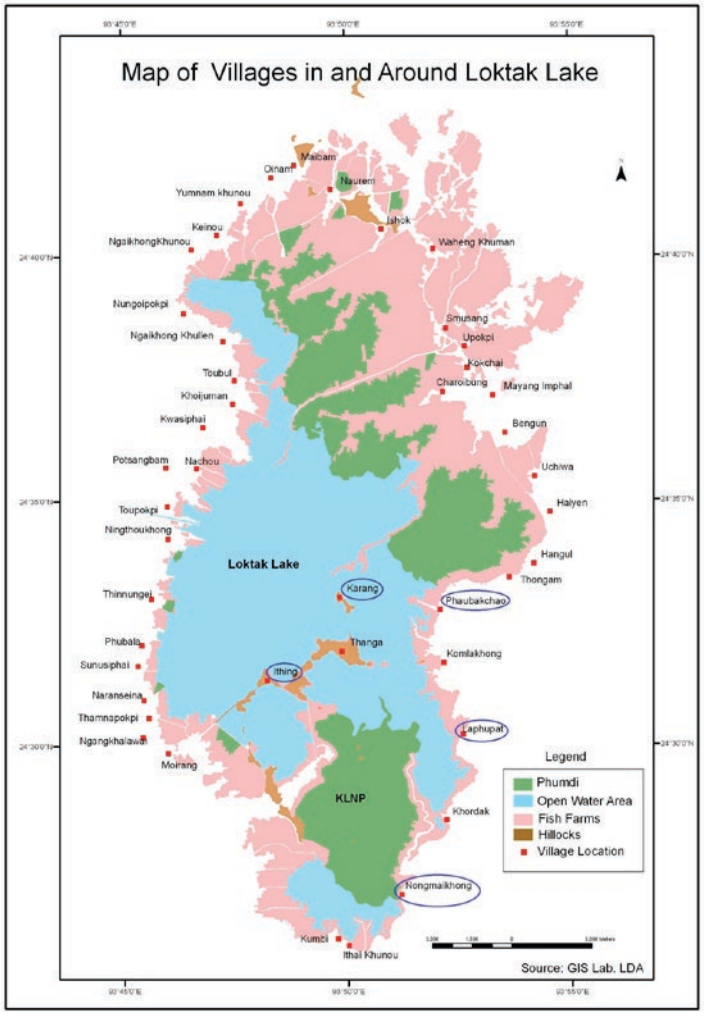

Figure 1. Map showing the study villages

Research design, data collection and statistical analyses

The present study was a household questionnaire survey of the people living in the five selected Loktak's lakeshore villages i.e. Nongmaikhong, Phoubakchao, Laphupat Tera, Karang and Ithing. These villages were selected purposively for the study based on their dependency on the lake and accessibility.

The questionnaire used in the present study was designed in English and asked in Manipuri, which is the local language of Manipur. The researcher being Manipuri translated the questionnaire by himself into Manipuri and asked the respondents directly in Manipuri only and noted down the answer in English. It sought to obtain information on the various decreasing bioresources of the Loktak lake used as food, for livelihood and income generation. The questionnaire was prepared referring Sah and Heinin 2001; Baral 2005; Baral and Heinin 2007. Purposive sampling technique of about 25% of households was adopted resulting in the selection of a total of 300 households- 40 households from Nongmaikhong, 100 from Phoubakchao, 80 from Laphupat Tera, 50 from Karang and 30 from Ithing (Sah and Heinin 2001; McElwee 2010). From the selected household the head of the family or any other adult member of the household - 20 years and above was selected as respondent. The numbers of the respondents per household was one i.e. head of the household or any adult member of the household age above 20 years in the absence of the household's head.

For identification of species the local names and specimen of the bioresources used by the respondents were collected and cross checked with the published literatures (Sinha 1996; Singh et al. 2000; Jayaram 2010; Vishwanath et al. 2014) and identified with the help of experts of Loktak Development Authority (LDA), Manipur. For the correct nomenclature of plant species International Plant Name Index (IPNI) (http://www.ipni.org) and The Plant List (http://www.theplantlist.org) websites were referred. Fish species were identified by using website such as https://www.fishbase.in. The data obtained from the survey was compiled and interpreted. Village-wise response percentage and overall percentage of the five villages was calculated for all the questions using Microsoft Excel.

Results and Discussion

The respondents in the present study were found to be poor with low total annual income. Among the five villages 45.67% earned Rs. 30,001 to 60,000 followed by 35.33% earning below Rs.30,000. 74% earned between Rs.30,001 to 60,000 annually in Karang village and 57% of Phoubakchao village earned below Rs. 30000 annually (Table-1). The decreasing bioresources of the Loktak lake used by the people living in the five study villages are presented in Table-2 and Table-3. The bio-resources are said to be decreasing as reported by the respondents. Some years back the quantity of fishes caught by the respondents were much higher as compared to present catch, so also, varieties of fishes were caught at one time was higher in past than present. Moreover, they also reported that other bioresources are decreasing in quantity and also their varieties. Table-2 shows decreasing bioresources of the Loktak

lake which is used as food. With respect to the fishes that are decreasing in all the five villages 34 species of fishes which are used by the local people for food were responded to be decreasing. In the overall percentage of all the five villages, 59.2% of the respondents reported *Osteobrama belangeri* (Pengba) to be highest. 90% of the respondents from Ithing village reported *Osteobrama belangeri* (Pengba) as highest. LDA and WISA (2003) reported about the presence of 53 types of fishes from the Loktak lake. Laishram and Dey (2013a) also reported that fishes and prawns were the major resources used from the lake and the people living in Ithing and Karang villages of Loktak Lake were found to be economically poor and the lake has been found in degrading conditions because of various threats.

Table-1 Total annual income

Particulars	V_1 N=40	V_2 N=100	V_3 N=80	V_4 N=50	V_5 N=30	Overall N=300
1) Below Rs.30,000	8 (20)	57 (57)	40 (50)	0 (0)	1 (3.33)	106 (35.33)
2) Rs. 30,001 to 60,000	21 (52.5)	40 (40)	31 (38.75)	37 (74)	8 (26.67)	137 (45.67)
3) Rs. 60,001-90,000	11 (27.5)	2 (2)	2 (2.5)	8 (16)	19 (63.33)	42 (14)
4) Above Rs. 90,000	0 (0)	1 (1)	7 (8.75)	5 (10)	2 (6.67)	15 (5)

Figure in parentheses indicate the percentage of each category
V_1= Nongmaikhong, V_2=Phoubakchao, V_3= Laphupat Tera, V_4=Karang, V_5=Ithing

Table-2 Decreasing bioresources of the Loktak lake used as food. (The figures under each village denote the number of responses (out of 300) against each bioresources which the respondents used and felt that are decreasing and figures inside the bracket are percentages).

Particulars		V_1 N=39	V_2 N=100	V_3 N=80	V_4 N=50	V_5 N=30	Overall N=299
1) Fishes							
Scientific name	**Local name**						
1) *Osteobrama belangeri* (Valenciennes)	Pengba	18 (46.15)	54 (54)	40 (50)	38 (76)	27 (90)	177 (59.2)
2) *Wallago attu* (Schneider)	Sareng	20 (51.28)	38 (38)	27(33.75)	40 (80)	21 (70)	146 (48.83)
3) *Mastacembelus armatus* (Lacepède)	Nganoi	4 (10.26)	6 (6)	3 (3.75)	1 (2)	5(16.67)	19 (6.35)
4) *Channa orientalis* Bloch & Schneider	Meeitei Ngamu	6 (15.38)	37 (37)	21(26.25)	11 (22)	11(36.67)	86 (28.76)
5) *Anguilla bengalensis* (Gray)	Ngaril laina	3 (7.69)	0 (0)	4 (5)	0 (0)	0 (0)	7 (2.34)
6) *Bangana dero* (Hamilton)	Khabak	7 (17.95)	34 (34)	17(21.25)	12 (24)	5 (16.67)	75 (25.08)
7) *Bangana devdevi* (Hora)	Ngaton	11 (28.21)	34 (34)	17(21.25)	21 (42)	12 (40)	95 (31.77)
8) *Chanda nama* Hamilton	Ngamhai	1 (2.56)	1 (1)	0 (0)	0 (0)	0 (0)	2 (0.67)
9) *Eutropiichthys vacha* (Hamilton)	Ngahei	1 (2.56)	2 (2)	2 (2.5)	0 (0)	0 (0)	5 (1.67)
10) *Lepidocephalichthys guntea* (Hamilton)	Ngakijou	1 (2.56)	19 (19)	4 (5)	0 (0)	0 (0)	24 (8.03)
11) *Clarias nagur* (Hamilton)	Ngakra	18 (46.15)	66 (66)	37(46.25)	17 (34)	12 (40)	150 (50.17)
12) *Trichogaster labiosus* (Day)	Phetin	1 (2.56)	12 (12)	0 (0)	0 (0)	0 (0)	13 (4.35)
13) *Gonorhynchus burmanicus* (Hora)	Ngaroi	0 (0)	9 (9)	3 (3.75)	0 (0)	0 (0)	12 (4.01)
14) *Hypsibarbus myithyinae* (Prasad & Mukherji)	Heikak nga	0 (0)	9 (9)	3 (3.75)	5 (10)	0 (0)	17 (5.69)
15) *Pangio pangia* (Hamilton)	Nganap	5 (12.82)	8 (8)	4 (5)	14 (28)	0 (0)	31 (10.37)
16) *Systomus sarana* (Hamilton)	Ngahou	0 (0)	11 (11)	3 (3.75)	0 (0)	0 (0)	14 (4.68)

17) *Mystus microphthalmus* (Day)	Nganan	1 (2.56)	0 (0)	6 (7.5)	0 (0)	0 (0)	7 (2.34)
18) *Mystus bleekeri* (Day)	Ngashep	3 (7.69)	4 (4)	0 (0)	17 (34)	3 (10)	27 (9.03)
19) *Osteobrama cotio* (Hamilton)	Ngaseksha	1 (2.56)	1 (1)	0 (0)	10 (20)	1 (3.33)	13 (4.35)
20) *Labeo calbasu* (Hamilton)	Ngathi	0 (0)	0 (0)	16 (20)	0 (0)	9 (30)	25 (8.36)
21) *Neolissocheilus hexagonolepis* (McClelland)	Ngara	2 (5.13)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.67)
22) *Channa punctata* (Bloch)	Ngamu	6 (15.38)	8 (8)	5 (6.25)	0 (0)	3 (10)	22 (7.36)
23) *Bagarius bagarius* (Hamilton-Buchanan)	Ngarel	1 (2.56)	1 (1)	3 (3.75)	0 (0)	0 (0)	5 (1.67)
24) *Ompok bimaculatus* (Bloch)	Ngaten	2 (5.13)	2 (2)	5 (6.25)	10 (20)	3 (10)	22 (7.36)
25) *Notopterus notopterus* (Hamilton-Buchanan)	Ngapai	0 (0)	0 (0)	0 (0)	1 (2)	0 (0)	1 (0.33)
26) *Anabas testudineus* (Bloch)	Ukabi	0 (0)	9 (9)	3 (3.75)	1 (2)	0 (0)	13 (4.35)
27) *Channa striata* (Bloch)	Porom	0 (0)	5 (5)	0 (0)	1 (2)	0 (0)	6 (2.01)
28) *Glyptothorax sp.* Blyth	Ngapang	0 (0)	2 (2)	1 (1.25)	0 (0)	0 (0)	3 (1)
29) *Garra naganensis* Hora	Ngamu sengum	0 (0)	2 (2)	4 (5)	0 (0)	0 (0)	6 (2.01)
30) *Synchrossus berdmorei* (Blyth)	Sareng Khoibi	0 (0)	3 (3)	5 (6.25)	0 (0)	0 (0)	8 (2.68)
31) *Pethia manipurensis* (Menon, Rena Devi, Vishwanath)	Ngakha Meinganbi	0 (0)	5 (5)	0 (0)	0 (0)	0 (0)	5 (1.67)
32) *Chitala chitala* (Hamilton)	Kandla	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	1 (0.33)
33) *Glossogobius giuris* (Hamilton)	Nylon ngamu	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	2 (0.67)
34) *Acanthocobitis botia* (Hamilton)	Ngatup	0 (0)	0 (0)	1 (1.25)	0 (0)	0 (0)	1 (0.33)
35) None	-	0 (0)	0 (0)	3 (3.75)	0 (0)	0 (0)	3 (1)
36) No idea	-	1 (2.56)	2 (2)	26 (32.5)	3 (6)	2 (6.67)	34 (11.37)
37) No response	-	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
		V_1 (N=7)	**V_2 (N=57)**	**V_3 (N=53)**	**V_4 (N=37)**	**V_5 (N=26)**	**N=180**
2) Prawns							
Scientific name	**Local name**						
1) *Macrobrachium dayanum* Henderson	Khajing	1 (14.29)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.56)
2) None	-	6 (85.71)	55 (96.50)	52 (98.11)	36 (97.3)	26 (100)	175 (97.22)
3) No idea	-	0 (0)	1 (1.75)	1 (1.89)	0 (0)	0 (0)	2 (1.11)
4) No response	-	0 (0)	1 (1.75)	0 (0)	1 (2.7)	0 (0)	2 (1.11)
		V_1(N=25)	**V_2(N=33)**	**V_3(N=34)**	**V_4 (N=3)**	**V_5 (N=2)**	**N=97**
3) Mollusca							
Scientific name	**Local name**						
1) *Turritella spp.*	Laitharoi	3 (12)	0 (0)	0 (0)	0 (0)	0 (0)	3 (3.09)
2) *Pila globosa* (Swainson)	Labuk tharoi	0 (0)	0 (0)	0 (0)	3 (100)	1 (50)	4 (4.12)
3) None	-	14 (56)	32 (96.97)	34 (100)	0 (0)	0 (0)	80 (82.47)
4) No idea	-	8 (32)	1 (3.03)	0 (0)	0 (0)	1 (50)	10 (10.32)
5) No response	-	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
		V_1 (N=38)	**V_2 (N=95)**	**V_3 (N=63)**	**V_4 (N=46)**	**V_5 (N=13)**	**N=255**
4) Vegetable items							
Scientific name	**Local name**						
1) *Persicaria barbata* (L.) H.Hara	Yellang	3 (7.89)	10 (10.53)	9 (14.29)	0 (0)	4 (30.77)	26 (10.2)

2) *Nymphoides indica* (L.) Kuntze	Yelli/ Thariktha-macha	4 (10.53)	45 (47.37)	15 (23.81)	24(52.17)	13 (100)	101 (39.61)
3) *Nymphaea pubescens* Willd.	Tharo	2 (5.26)	1 (1.05)	1 (1.59)	0 (0)	4 (30.77)	8 (3.14)
4) *Alpinia nigra* (Gaertn.) B.L.Burtt	Pullei	1 (2.63)	1 (1.05)	1 (1.59)	1 (2.17)	0 (0)	4 (1.57)
5) *Ipomoea aquatica* Forssk.	Kollamni	1 (2.63)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.39)
6) *Euryale ferox* Salisb.	Thangjing	0 (0)	0 (0)	0 (0)	0 (0)	1 (7.69)	1 (0.39)
7) *Hedychium coronarium* J.Koenig	Loklei	0 (0)	1 (1.05)	0 (0)	2 (4.35)	0 (0)	3 (1.18)
8) *Lysimachia obovata* Buch.-Ham. ex Wall.	Kengoi	0 (0)	4 (4.21)	0 (0)	0 (0)	0 (0)	4 (1.57)
9) *Zizania latifolia* (Griseb.) Turcz. ex Stapf	Ishing Kambong	0 (0)	6 (6.32)	0 (0)	0 (0)	0 (0)	6 (2.35)
10) None	-	7 (18.42)	24 (25.26)	25 (39.68)	19 (41.3)	0 (0)	75 (29.41)
11) No idea	-	20 (52.63)	14 (14.74)	15 (23.81)	6 (13.04)	0 (0)	55 (21.57)
12) No response	-	2 (5.26)	3 (3.16)	0 (0)	0 (0)	0 (0)	5 (1.96)

Figure in parentheses indicate the percentage of each category
V_1= Nongmaikhong, V_2=Phoubakchao, V_3= Laphupat Tera, V_4=Karang, V_5=Ithing

Only 1 species of prawn was reported to decrease from the lake in the study. 0.56% of the respondents were of the opinion that prawn species i.e. *Macrobrachium dayanum* (Khajing) is decreasing. Laishram and Dey (2013b) also found that the local communities living in five villages located in and around the Loktak lake depended on the lake for fishing, collection of vegetables, and prawns etc. for their livelihood.

In the present study 2 species of mollusks were reported to have decreased from the Loktak lake. Overall, 4.12% of the respondents felt that species of mollusca such as *Pila globosa* (Labuk tharoi) was decreasing while 100% of Karang village respondents felt the same. Similar study was conducted by Kumar (2013) where the Kabartal wetland, Bihar, India was used for water supply, irrigation, domestic purposes, fishing, netting of migratory waterfowl for sale, harvesting of wild rice and gathering of the edible mollusk, *Pila globosa* and edible plant product such as *Singhada* (*Trapa natans*), Water chestnut (*Eleocharis dulcis*), *Makhana* or foxnut (*Euryale ferox*).

9 species of vegetable items were responded to have decreased from the lake. Overall, 39.61% of respondents were of the opinion that *Nymphoides indica* (Yelli/Thariktha-macha) was declining and 100% of the respondents from Ithing village also said that *Nymphoides indica* (Yelli/Thariktha-macha) was declining. Singh (2002) identified 54 species of plants available on the *Phumdis* of Loktak lake, Manipur, India having importance to the local people for their livelihood and were found to be used for edible, cultural, medicinal, fodder, house making and biofertilizer purposes. Singh and Singh (1994) also found *Euryale ferox, Ipomoea* sp. and *Nymphaea alba* as some of the economically prominent species of biotic resources found in Loktak lake and used by the local communities.

Table-3 Other bioresources of the Loktak lake that are decreasing

(The figures under each village denotes the no. of responses (out of 300) against each bioresources which the respondents used and felt that are decreasing and figures inside the bracket denotes conversion of those responses into percentages)

Particulars		**V_1 N=0**	**V_2 N=31**	**V_3 N=10**	**V_4 N=0**	**V_5 N=0**	**Overall N=41**
1) Fodders							
Scientific name	**Local name**						
1) *Echinochloa stagnina* (Retz.) P.Beauv.	Hup	0 (0)	2 (6.45)	5 (50)	0 (0)	0 (0)	7 (17.07)
2) *Ludwigia octovalvis* subsp. *brevisepala* (Brenan) P.H.Raven	Tebo	0 (0)	2 (6.45)	0 (0)	0 (0)	0 (0)	2 (4.88)
3) *Oryza rufipogon* Griff.	Wainu chara	0 (0)	1 (3.23)	0 (0)	0 (0)	0 (0)	1 (2.44)
4) *Eleusine indica* (L.) Gaertn.	Phungpai	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5) None	-	0 (0)	20 (64.52)	2 (20)	0 (0)	0 (0)	22 (53.66)
6) No idea	-	0 (0)	6 (19.35)	0 (0)	0 (0)	0 (0)	6 (14.63)
7) No response	-	0 (0)	0 (0)	3 (30)	0 (0)	0 (0)	3 (7.32)
		V_1 (N=33)	**V_2 (N=94)**	**V_3 (N=60)**	**V_4 (N=39)**	**V_5 (N=4)**	**N=230**
2) Fuelwoods							
Scientific name	**Local name**						
1) *Saccharum narenga* (Nees ex Steud.) Hack.	Singmut	8 (24.24)	18 (19.15)	34 (56.67)	5 (12.82)	0 (0)	65 (28.26)
2) *Saccharum arundinaceum* Retz.	Singnang	5 (15.15)	11 (11.7)	25 (41.67)	4 (10.26)	2 (50)	47 (20.43)
3) *Quercus lamellosa* Sm.	Uyung	0 (0)	0 (0)	1 (1.67)	0 (0)	0 (0)	1 (0.43)
4) *Phragmites karka* (Retz.) Trin. ex Steud.	Tou	0 (0)	0 (0)	0 (0)	1 (2.56)	0 (0)	1 (0.43)
5) *Eleutherococcus trifoliatus* (L.) S.Y.Hu	Chongang	0 (0)	10 (10.64)	0 (0)	0 (0)	0 (0)	10 (4.35)
6) *Coix lacryma-jobi* L.	Yawa	0 (0)	12 (12.77)	0 (0)	0 (0)	0 (0)	12 (5.22)
7) *Mitragyna diversifolia* (Wall. ex G. Don) Havil.	Chomlang	0 (0)	4 (4.26)	0 (0)	0 (0)	0 (0)	4 (1.74)

8) *Persicaria orientalis* (L.) Spach	Chaokhong	0 (0)	1 (1.06)	0 (0)	0 (0)	0 (0)	1 (0.43)
9) None	-	6 (18.18)	41 (43.62)	17 (28.33)	24 (61.54)	0 (0)	88 (38.26)
10) No idea	-	17 (51.52)	15 (15.96)	5 (8.33)	8 (20.51)	2 (50)	47 (20.43)
11) No response	-	1 (3.03)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.43)
		V_1 (N=19)	**V_2 (N=53)**	**V_3 (N=45)**	**V_4 (N=16)**	**V_5 (N=1)**	**N=134**
3) Thatch grasses							
Scientific name	**Local name**						
1) *Imperata cylindrica* (L.) Raeusch.	Ee	0 (0)	1 (1.89)	10 (22.22)	5 (31.25)	0 (0)	16 (11.94)
2) *Cymbopogon citratus* (DC.) Stapf	Charot	1 (5.26)	5 (9.43)	0 (0)	0 (0)	0 (0)	6 (4.48)
3) *Carex cruciata* Wahlenb.	Humdang	4 (21.05)	7 (13.21)	0 (0)	0 (0)	0 (0)	11 (8.21)
4) *Chrysopogon zizanioides* (L.) Roberty	Tumnou	0 (0)	3 (5.66)	4 (8.89)	0 (0)	0 (0)	7 (5.22)
5) None	-	3 (15.79)	32 (60.38)	15 (33.33)	3 (18.75)	0 (0)	53 (39.55)
6) No idea	-	11 (57.89)	10 (18.87)	16 (35.56)	7 (43.75)	1 (100)	45 (33.58)
7) No response	-	1 (5.26)	0 (0)	0 (0)	1 (6.25)	0 (0)	2 (1.49)
		V_1 (N=1)	**V_2 (N=20)**	**V_3(N=25)**	**V_4 (N=4)**	**V_5 (N=1)**	**N=51**
4) Medicinal plants							
Scientific name	**Local name**						
1) *Stephania glabra* (Roxb.) Miers	Koubruyai	0 (0)	3 (15)	0 (0)	0 (0)	0 (0)	3 (5.88)
2) None	-	0 (0)	9 (45)	14 (56)	0 (0)	0 (0)	23 (45.1)
3) No idea	-	1 (100)	8 (40)	11 (44)	3 (75)	1 (100)	24 (47.06)
4) No response	-	0 (0)	0 (0)	0 (0)	1 (25)	0 (0)	1 (1.96)
		V_1 (N=12)	**V_2 (N=24)**	**V_3 (N=28)**	**V_4 (N=12)**	**V_5 (N=0)**	**N=76**
5) Handicraft materials							
Scientific name	**Local name**						
1) *Schoenoplectus lacustris* (L.) Palla	Kouna	0 (0)	2 (8.33)	0 (0)	6 (50)	0 (0)	8 (10.53)
2) *Cyperus alternifolius* L.	Chumthang	3 (25)	2 (8.33)	0 (0)	0 (0)	0 (0)	5 (6.58)
3) None	-	2 (16.67)	17 (70.84)	22 (78.57)	3 (25)	0 (0)	44 (57.89)
4) No idea	-	7 (58.33)	3 (12.5)	6 (21.43)	3 (25)	0 (0)	19 (25)
5) No response	-	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Figure in parentheses indicate the percentage of each category

V_1= Nongmaikhong, V_2=Phoubakchao, V_3= Laphupat Tera, V_4=Karang, V_5=Ithing

Table-3 presents other bioresources of the Loktak lake that are decreasing as per the survey response. In all 4 species of fodder were found to decrease from the Loktak lake. In the overall percentage of the fodder that are decreasing 17.07% responded *Echinochloa stagnina* (Hup) was highest. Among the villages 50% of the respondents in Laphupat Tera village responded *Echinochloa stagnina* (Hup) was highest.

A total of 8 species of fuelwoods were reported to decrease from the lake. In the overall percentage of the fuelwoods that are decreasing, 28.26% responded *Saccharum narenga* (Singmut) was highest. Among the villages 56.67% of the respondents in Laphupat Tera village responded *Saccharum narenga* (Singmut) was highest. LDA and WISA (2003) also reported that species like *Phragmites karka* used as fuel is declining from the Loktak lake.

Four thatch grasses species were reported to have decreased from the lake. In the overall percentage of the thatch grasses that are decreasing 11.94% responded *Imperata cylindrica* (Ee) was highest. 31.25% of the respondents in Karang village responded *Imperata cylindrica* (Ee) was highest. Devi et al. (2014) noted that *Cymbopogon citrates*, *Imperata cylindrica*, *Phragmites karka*, *Saccharum arundinaceum* and *Saccharum procerum* collected from Loktak lake were used as thatching, fodder and fuel materials.

In the present study 1 species of medicinal plants was reported to decrease from the lake. Among the percentage of all the villages relating to the medicinal plants that are decreasing only *Stephania glabra* (Koubruyai) was responded by 5.88%. Panda and Misra (2011) found that 48 wetland plants under 40 genera and 23 families were used by the local people against 47 ailments.

2 species of handicraft materials were responded as decreasing from the Loktak lake. Overall percentage of the handicraft materials that are decreasing are 10.53% for *Schoenoplectus lacustris* (Kouna) and 6.58% for *Cyperus alternifolius* (Chumthang). 10.53% and 6.58% were of the opinion that *Schoenoplectus lacustris* (Kouna) and *Cyperus alternifolius* (Chumthang) have become rare. 57.89% said "None" and 25% had "No idea". *Schoenoplectus lacustris* (Kouna) was responded by 50% from Karang village to be rarest. WISA (2005) also reported that communities living in and around Loktak and associated wetlands are directly or indirectly dependent upon the lake resources for sustenance and the lake serves as an important source of various resources including fisheries, vegetation and water, food, fuel, fodder, thatching material, medicinal plants, raw materials for handicrafts etc.

In this study high dependency of the people residing in the five selected Loktak's lakeshore villages for various purposes like food (69.25%), fodder (13.67%), fuelwood (76.67%), building of houses (44.67%), medicinal purposes (17%) and for handicraft (25.33%) was observed. The dependency on Loktak lake by the people was found to be for consumption and household income but due to various human pressures the lake was found to be polluted and degradation of the surrounding natural environment occurred resulting in depletion of bioresources available in the Loktak lake and poor socio-economic condition of the community. Laishram and Dey (2013a) also reported that the causes of depletion of the Loktak lake resources and degradation of the lake is due to anthropogenic activities like siltation, unsustainable agricultural practices, water pollution, construction of Ithai dam, encroachments in the lake by constructing fishponds, construction of roads and settlements.

Conclusion

In the present study it is found that the people residing in the five study villages i.e. Nongmaikhong, Phoubakchao, Laphupat Tera, Karang and Ithing were found to be poor and are dependent on the Loktak lake for nine types of bioresources like fishes (99.67%), prawn (60%), mollusks (32.33%), vegetable items (85%), fodder (13.67%), fuelwood (76.67%), thatch grasses (44.67%), medicinal plants (17%) and handicrafts materials (25.33%) for livelihood and income generation. The concerned authorities need to adopt suitable policies and conservation measures for the conservation and sustainable management of the lake and its bioresources. Involvement of the local people in the conservation and sustainable management of the lake and its bioresources is also necessary.

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Author Contributions

Jogesh Laishram and Mithra Dey both designed the research work. Field survey, data collection, data analysis and writing of the manuscript were done by Jogesh Laishram. Mithra Dey helped in checking and finalising the manuscript.

Appendix

Questionnaire

Household serial number _____# Date of survey _____

1) Name of the village _____2) District _____

3) Name of household head _____Age _____

1) Male □ 2) Female □

4) Name of the respondent _____Age _____

1) Male □ 2) Female □

5) Size of the household _____

6) Total annual income

Particulars	V_1	V_2	V_3	V_4	V_5	Overall
1) Below Rs.30,000/-						
2) Rs. 30,001 to 60,000/-						
3) Rs. 60,001-90,000/-						
4) Above Rs. 90,000/-						

V_1= Nongmaikhong, V_2=Phoubakchao, V_3= Laphupat Tera, V_4=Karang, V_5=Ithing

7) Decreasing bioresources of Loktak lake used as food

Particulars		V_1	V_2	V_3	V_4	V_5	Overall
1) Fishes							
Scientific name	**Local name**						
2) Prawns							
Scientific name	**Local name**						
3) Snails							
Scientific name	**Local name**						
4) Mussels							
Scientific name	**Local name**						
5) Vegetable items							
Scientific name	**Local name**						

V_1= Nongmaikhong, V_2=Phoubakchao, V_3= Laphupat Tera, V_4=Karang, V_5=Ithing

8) Other bioresources of Loktak lake that are decreasing

Particulars		**V_1**	**V_2**	**V_3**	**V_4**	**V_5**	**Overall**
1) Fodders							
Scientific name	**Local name**						
2) Fuelwoods							
Scientific name	**Local name**						
3) Thatch grasses							
Scientific name	**Local name**						
4) Medicinal plants							
Scientific name	**Local name**						

5) Handicraft materials							
Scientific name	**Local name**						

V_1= Nongmaikhong, V_2=Phoubakchao, V_3= Laphupat Tera, V_4=Karang, V_5=Ithing

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Butterfly diversity at Uplaon Nature Park, Kalaburagi district, Karnataka, India

Kavya. K Saraf* and K Vijayakumar[2]

Kavya K Saraf, Affiliation - Department of Post Graduate Studies and research in Zoology, Gulbarga University, Kalaburagi- 585106, Karnataka, India.
Complete Postal Address – 4-601/44/B/2-C,: Kavya Sadan", Near Raghavendra Temple, M.B. Nagar, Gulbarga- 585105, Kalaburagi, Karnataka. Email - kkavyaksaraf@gmail.com (Corresponding Author)
ORCID Kavya – 0000-0002-3197-1796
Contact number – 9916410966

K Vijayakumar, Affiliation - Department of Post Graduate Studies and research in Zoology, Gulbarga University, Kalaburagi- 585106, Karnataka, India.
Complete Postal Address - Department of Post Graduate Studies and research in Zoology, Gulbarga University, Kalaburagi- 585106, Karnataka, India. Email –katepaga63@gmail.com
ORCID Vijaykumar – 0000-0001-5567-6794

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Abstract: A total of 83 butterfly species belonging to five families, with 6 species in Papilionidae, 7 species in Hesperiidae, 21 species in Pieridae, 25 species in Lycaenidae and 24 species in Nymphalidae families . were recorded from April 2015 to December 2017 from Uplaon Nature Camp, Kalaburagi district, Karnataka. All the 83 species of butterflies were distributed under one Superfamily Papilionoidea, and five families, 16 subfamilies, 19 tribes and 48 genera.

Key words: Ecology; Diversity; Butterflies; Indicators; Conservation; Kalaburagi

Introduction

After bees, butterflies are very specific to their food plants. Butterflies being attractive than most other insects are referred to as 'Flagship' and 'honorary birds' (Ghazoul 2002). They are valuable pollinators, important food chain components of birds, reptiles, spiders, and predatory insects; they are also the good indicators of environmental quality (Ghazoul 2002). They are valuable pollinators in the local environment

and help in pollinating more than 50 economically important crops (Borges et al. 2003). They are one of the important food chain components of birds, reptiles, spiders and predatory insects (Thomas, et al. 1998). The larvae, which feed on foliage, are primary herbivores in the ecosystem and are important in the transfer of energy fixed by plants, making them available to the other organisms in the ecosystem. Adult butterflies are dependent on nectar and pollen as their food while the caterpillars are dependent on specific host plant for foliage. Butterflies bear a history of long-term coevolution with plants and faunistic survey of butterflies, their occurrence and characteristics provide crucial information on the ecology of a particular region (Ghazoul 2002). 19,238 species of butterflies have been documented from all over the world (Ghazoul, 2002), among them 1501 species of butterflies are recorded from India (Kunte et al.1999) out of which 962 species have been reported from North eastern part (Evans 1932), 332 species from the Western Ghats and 150 from Eastern Ghats (Ashish et al. 2009). Out of 332 species of Western Ghats 37 species are endemic (Kunte 2000; Prajapati 2010). Being good indicators of climatic conditions as well as seasonal and ecological changes, they can serve in formulating strategies for conservation. However, they were largely been ignored by conservation biologist and policy makers as well. It is hence encouraging that butterflies are now being included in biodiversity studies and biodiversity conservation prioritization programme (Gadgil 1996). In this paper, an attempt is made to document the butterfly diversity (species richness and abundance) of Uplaon Nature Park, Kalaburagi District, Karnataka, India.

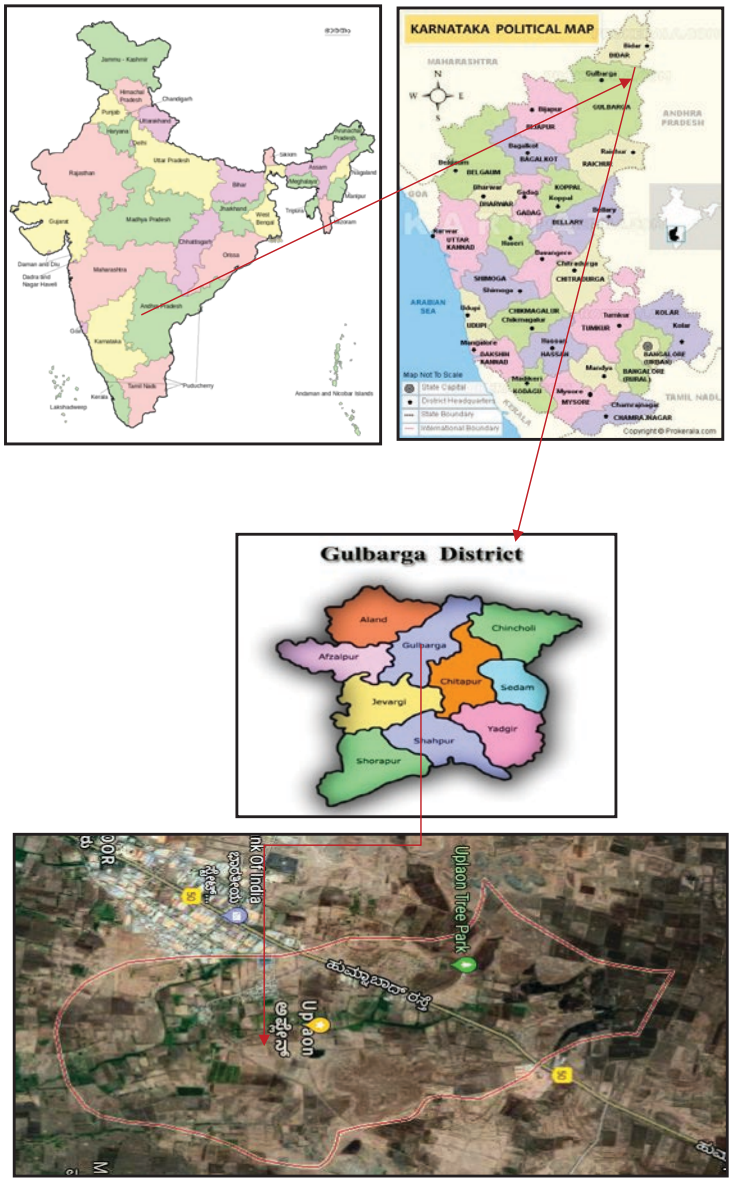

Figure 1. Research station - Uplaon nature Park, Kalaburagi district Karnataka, India.

Material and methods

Study area:

Kalaburagi district is situated in northern Karnataka between 76°.04' and 77°.42 East longitude, and 17°.12' and 17°.46' North latitude, covering an area of 10,951 km². Kalaburagi district has a semi-arid type of climate. During peak summer maximum temperature reaches 45^{0}C and December is the coldest month with minimum temperature 10^0 to 15^0 C, Average rain fall 1-839mm. (Reference – Kalaburagi District Profile Government of Karnataka: the knowledge hub Asia)

Uplaon Nature Park lies on the geographical coordinates of 17^0 23'39.1826'' N and 76^0 52' 33.5019''E and at an altitude of 471m above mean sea level situated about 13 km away from Kalaburagi Central bus stand, of survey number 16, with a geographical area 44.05 acre (18.88 Hectare.), comes under Kalaburagi District, Karnataka State, India.

Butterfly diversity study

Field observations were made 3 days in a week continuously (From Sunday to Wednesday) for three years from April 2015 to December 2017. Observations were made between 8 am to 12 pm. (8:00h and 12:00h). The butterfly species belonging to the Families, Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae and Pieridae were recorded by direct visual field observations and photographic evidence.

Lycaenidae butterflies which are difficult to identify were photographed for relevant distinctive characteristics with digital cameras (Dayanada, 2014).

Most of the Hesperiidae species were could not be identified up to species level without dissecting their male genitalia; therefore, we recorded them up to genus level. The key characters used for identification were color pattern and wing span (Evan 1932; Wynter-Blyth 1957) and also by using field guides, Hand book, and butterfly lists for India. (Gupta and Mridula 2012; Kishandas 2013; Gunathilagaraj et al.,2015; Varshney and Peter Smetacek 2015; Isaac 2016; Raju 2016) Further the butterflies were identified and confirmed by following Lepidopterists: Isaac Kehimkar, Moonson Jyoti Gogoi, Sammilan Shetty, Kamal Azad and Neha Mujumdar**.** All Scientific names, Common English names, and Classification of butterflies followed Varshney and Peter (2015), based on biological species concept.

Results And Discussion

A total of 83 butterfly species belonging to five families: Papilionidae, Hesperiidae, Pieridae, Lycaenidae and Nymphalidae had been recorded from June 2015 to December 2017. All the 83 species of butterflies distributed under one Superfamily Papilionoidea, and five families, 16 subfamilies, 19 tribes and 48 genera. Six species recorded in the family Papilionidae, seven species recorded in Hesperiidae, 21 species recorded in the family Pieridae, 25 species recorded in Lycaenidae and 24 species recorded in Nymphalidae family. All the recorded species have been listed in table 1, the number of subfamilies, tribe, genus and species number recorded in each family given in the table 2. Lycaenidae is the dominant family with 25 species and least number of species recorded in Papilionidae with six species. 463 individuals were counted in the family Papilionidae, 280 individuals in Hesperiidae, 983 in Pieridae, 1060 in Lycaenidae and 1249 in Nymphalidae during the research period.

Among the 83 species recorded seven species of butterflies possesses protected status under the Indian Wildlife (Protection) Act, 1972. *Pachliopta hector* (Crimson rose - Papilionidae) is in Schedule I (Part IV), *Spindasis elima* (Scarce Shot Silverline - Lycaenidae) in Schedule II (Part II), *Prioneris situ* (Painted Sawtooth - Pieridae) in Schedule IV , *Cepora nerissa* (Common Gull -Pieridae) in Schedule II (Part II), *Lampides boeticus* (Peablue - Lycaenidae) Schedule II (Part II), *Castalius rosimon* (Common Pierrot - Lycaenidae) in Schedule I (Part IV) and *Hypolimnas misippus* (Danaid Eggfly - Nymphalidae) Schedule II (Part II) and two species listed in Red Data Book, one in family Papilionidae- *Pachliopta hector* (Crimson Rose) and one in Nymphalidae - *Hypolimnas misippus* (Danaid Eggfly) listed in Least Concern category Sulochana and Murali (2014) reported butterfly fauna from Ankalga village, Kalaburagi district, Karanataka; their study reported 31 butterfly species, four in Papilionidae, 10 in Pieridae, five in Lycaenidae, 11 in Nymphalidae and one species in Hesperiidae. Nymphalidae was the dominant family followed by Pieridae, Lycaenidae, Papilionidae and Hesperiidae. Nandini and Murali (2014) reported 13 species from agriculture field at Hadgil Harutti, Kalaburagi district, Karnataka. In their study Pieridae was the dominant family with six species and two species were recorded in Papilionidae.

In our study Lycaenidae was dominant family and

least species were recorded in Papilionidae and seven species recorded in Hesperiidae family. There is a major difference in the species recorded in families and also the species richness of butterflies within in the Kalaburagi district, this is mainly because of the nectar and host plant availability of butterflies in their specific site. Nautiyal et al. (2013) reported 28 species of butterflies from in and around uranium mining area of Gogi Yadgir district Karnataka. Nymphalidae was the dominant family with 13 species; second dominant family was Papilionidae with six species, five species in Pieridae, two species in Lycaenidae, one species each in Satyridae and Hesperiidae. This result was quite different from our study report, Lycaenidae is the dominat family at Uplaon Nature Park with 25 species and seven species were in Hesperiidae. This variation in population between the areas which are facing almost same climatic condition could be because of their host (nectar and larval host plants) plants, and pollution in case of Gogi.

At Uplaon Nature Park grazing had been observed during the study period. Grazing by domestic cattle and artificial fire are the two important factors that imbalances the species richness, species abundance, species composition of population and entire community of the landscapes (Rodgers1986). Cattle uproot grasses while feeding on them grazing replaces palatable plant species with non-palatable invaders and weeds (Anderson1982), the result of this change in plant species composition and distribution which directly affects the butterfly population. Hence, proper management of Uplaon Nature Park will surely help to maintain the rich butterfly diversity.

In urban ecosystems, monitoring species diversity can be used as a tool to reduce human mismanagement and pollution in urbanized industrial and managed area (Wilson 1997). Diversity of butterflies is adversely affected by grass cutting and unauthorized grazing, fire and unscientific mowing. Seven species of butterflies recorded from study area possess a protected status under the Indian Wildlife (Protection) Act, 1972. Presence of these schedule species in the study area reveals that the area is rich in butterfly diversity and there is an urgent need to adapt conservation policies. The control of fire and grazing may be the first step to maintain diversity of butterflies at Uplaon Nature Park, Kalaburagi District Karnataka.

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Author Contributions:

Survey and Data collection, Laboratory Experimental work, Manuscript Preparation, Data analysis, and Design of the study - Kavya. K Saraf*

Original Idea, Design of the study - K Vijayakumar[2]

Table 1. Checklist of butterfly species recorded in Uplaon Nature Park, Kalaburagi district, Karnataka, India

S.No.	Scientific name	English name
Order –Lepidoptera, Suborder – Rhopalocera, Superfamily – Papilionoidea		
Family – Papilionidae		
Subfamily – Papilioninae		
Tribe 1 – Troidini		
1	*Pachliopta aristolochiae* (Fabricius,1775)	Common Rose
2	*Pachliopta hector* (Linnaeus, 1758)	Crimson Rose
Tribe 2 – Papilionini		
3	*Papilio demoleus* (Linnaeus, 1758)	Lime Butterfly
4	*Papilio polytes* (Linnaeus, 1758)	Common Mormon
Tribe 3- Leptocircini		
5	*Graphium agamemnon* (Linnaeus, 1758)	Tailed Jay

6	*Graphium doson* (C.&R. Felder. 1864)	Common Jay
Family – Hesperiidae,		
Subfamily – Coeliadinae		
7	*Hasora badra* (Moore, 1858)	Common Awl
8	*Hasora chromus* (Cramer, 1780)	Common Banded Awl
Subfamily – Hesperiinae		
Tribe 1 – Baorini		
9	**Pelopidas agna* (Moore, 1866)	Dark Branded Swift
10	**Pelopidas manthias* (Fabricius, 1798)	Small Branded Swift
11	**Pelopidas subochracea* (Moore, 1878)	Large Branded Swift
12	**Potanthus pseudomaesa* (Moore, 1881)	Indian Dart
Tribe 2 – Taractrocerini		
13	**Potanthus trachala (Mabille, 1881)*	Broad Bi –dent Dart
I. Family – Pieridae,		
Subfamily – Coliadinae		
14	*Catopsilia Pomona* (Fabricius, 1775)	Common Emigrant
15	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled Emigrant
16	*Eurema andersoni* (Moore, 1886)	One-spot Grass Yellow
17	*Eurema blanda* (Boisduval, 1836)	Three-spot Grass Yellow
18	*Eurema brigitta* (Stoll, 1780)	Small Grass Yellow
19	*Eurema hecabe* (Linnaeus, 1758)	Common Grass Yellow
20	*Eurema laeta* (Boisduval, 1836)	Spotless Grass Yellow
Subfamily – Pierinae		
Tribe1 – Pierini		
21	*Leptosia nina* (Fabricius, 1793)	Psyche
22	*Ixias Marianne* (Cramer, 1779)	White Orange Tip
23	*Ixias pyrene* (Linnaeus, 1764)	Yellow Orange Tip
24	*Colotis amata* (Cramer, 1775)	Small Salmon Arab
25	*Colotis aurora* (Cramer, 1780)	Plain Orange Tip
26	*Colotis danae* (Fabricius, 1775)	Crimson Tip
27	*Colotis etrida* (Boisduval, 1836)	Little Orange Tip
28	*Colotis fausta* (Olivier, 1804)	Large Salmon Arab
29	*Prioneris situ* (C.&R. Felder, 1865)	Painted Sawtooth
30	*Belenois aurota* (Fabricius, 1793)	Pioneer
31	*Cepora nerissa* (Fabricius, 1775)	Common Gull
32	*Delias eucharis* (Drury, 1773)	Common Jezabel
Tribe 2 - Euchloeini		
33	*Pareronia valeria* (Cramer, 1776)	Common Wanderer

34	*Hebomoia glaucippe* (Linnaeus, 1758)	Great Orange Tip
Family – Lycaenidae		
Subfamily – Curetinae		
35	*Curetis thetis* (Drury, 1773)	Indian Sunbeam
Subfamily – Aphnaeinae		
36	*Spindasis elima* (Moore, 1877)	Scarce Shot Silverline
37	*Spindasis ictis* (Hewitson, 1865)	Common Shot Silverline
38	*Spindasis vulcanus* (Fabricius, 1775)	Common Silverline
Subfamily – Theclinae		
Tribe 1 – Deudorigini		
39	*Deudorix epijarbas* (Moore, 1857)	Cornelian
Subfamily – Polyommatinae		
Tribe 2 – Polyommatini		
40	*Prosotas nora* (C. Felder, 1860)	Common Lineblue
41	*Jamides bochus* (Stoll, 1782)	Dark Cerulean
42	*Catochrysops panormus* (C.Felder, 1860)	Silver Foretmenot
43	*Catochrysops strabo strabo* (Fabricius, 1793)	Forgetmenot
44	*Lampides boeticus* (Linnaeus, 1767)	Peablue
45	*Leptotes plinius* (Fabricius, 1793)	Zebra Blue
46	*Castalius rosimon* (Fabricius, 1775)	Common Pierrot
47	*Tarucus extricates* (Butler, 1886)	Rounded Pierrot
48	Tarucus nara (Kollar, 1848)	Striped Pierrot
49	*Zizeeria karsandra* (Moore, 1865)	Dark Grass Blue
50	*Zizeeria otis* (Fabricius, 1787)	Lesser Grass Blue
51	*Everes lacturnus* (Godart, 1824)	Indian Cupid
52	*Azanus jesous* (Guerin – Meneville, 1849)	African Babul Blue
53	*Azanus ubaldus* (Stoll, 1782)	Bright Babul Blue
54	*Azanus Uranus* (Butler, 1886)	Dull Babul Blue
55	*Euchrysops cnejus* (Fabricius, 1798)	Gram Blue
56	*Freyeria putli* (Kollar, 1844)	Small Grass Jew
57	*Freyeria trochylus* (Freyer, 1845)	Grass Jewel
58	*Luthrodes pandava* (Horsfield, 1829)	Plains Cupid
59	*Chilades parrhasius* (Fabricius, 17930	Small Cupid
Family Nymphalidae		
Subfamily – Danainae		
Tribe 1 – Danaini		
60	*Danaus chrysippus* (Linnaeus, 1758)	Plain Tiger
61	*Danaus genutia* (Cramer, 1779)	Common Tiger
62	*Tirumala limniace* (Cramer, 1775)	Blue Tiger
63	*Tirumala septwntrionis* (Butler, 1874)	Dark Blue Tiger
Tribe 2 - Euploeini		
64	*Euploea core* (Cramer, 1780)	Common crow
65	*Euploea klugii* (Moore, 1858)	King Crow

66	*Euploea Sylvester* (Fabricius, 1793)	Double – branded Crow
Subfamily – Charaxinae		
67	*Charaxes solon* (Fabricius, 1793)	Black Rajah
Subfamily – Satyrinae		
Tribe 3 – Melanitini		
68	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown
69	*Ypthima asterope* (Klug, 1832)	Common Threering
Tribe 4 -Satyrini		
70	*Ypthima huebneri* (Kirby, 1871)	Common Fourring
Subfamily – Heliconiinae		
Tribe 5 – Heliconiini		
71	*Phalanta phalantha* (Drury, 1773)	Common Leopard
Subfamily – Biblidinae		
Tribe 6 – Biblidini		
72	*Ariadne ariadne* (Linnaeus, 1763)	Angled Castor
73	*Ariadne merione* (Cramer, 1777)	Common Castor
74	*Byblia ilithyia* (Drury, 1773)	Joker
Subfamily – Nymphalinae		
Tribe 7 – Nymphalini		
75	*Vanessa cardui* (Linnaeus, 1758)	Painted Lady
Tribe 8 – Junoniini		
76	*Junonia almana* (Linnaeus, 1758)	Peacock Pansy
77	*Junonia atlites* (Linnaeus, 1763)	Grey Pansy
78	*Junonia hierta* (Fabricius, 1798)	Yellow Pansy
79	*Junonia lemonias* (Linnaeus, 1758)	Lemon Pansy
80	*Junonia orithya* (Linnaeus, 1758)	Blue Pansy
Tribe 9 – Kallimini		
81	*Hypolimnas bolina* (Linnaeus, 1758)	Great Eggfly
82	*Hypolimnas misippus* (Linnaeus, 1764)	Danaid Eggfly
Subfamily – Acraeinae		
Tribe 10 – Acraeini		
83	*Acraea violae* (Fabricius, 1793)	Tawny Coster

[* Those species of Hesperiidae family need further studies, Hesperiidae family butterflies are very difficult to identify without collecting the specimens. I hope to obtain permission to collected specimens in future to dissect their genitalia to identify and confirm the species names.]

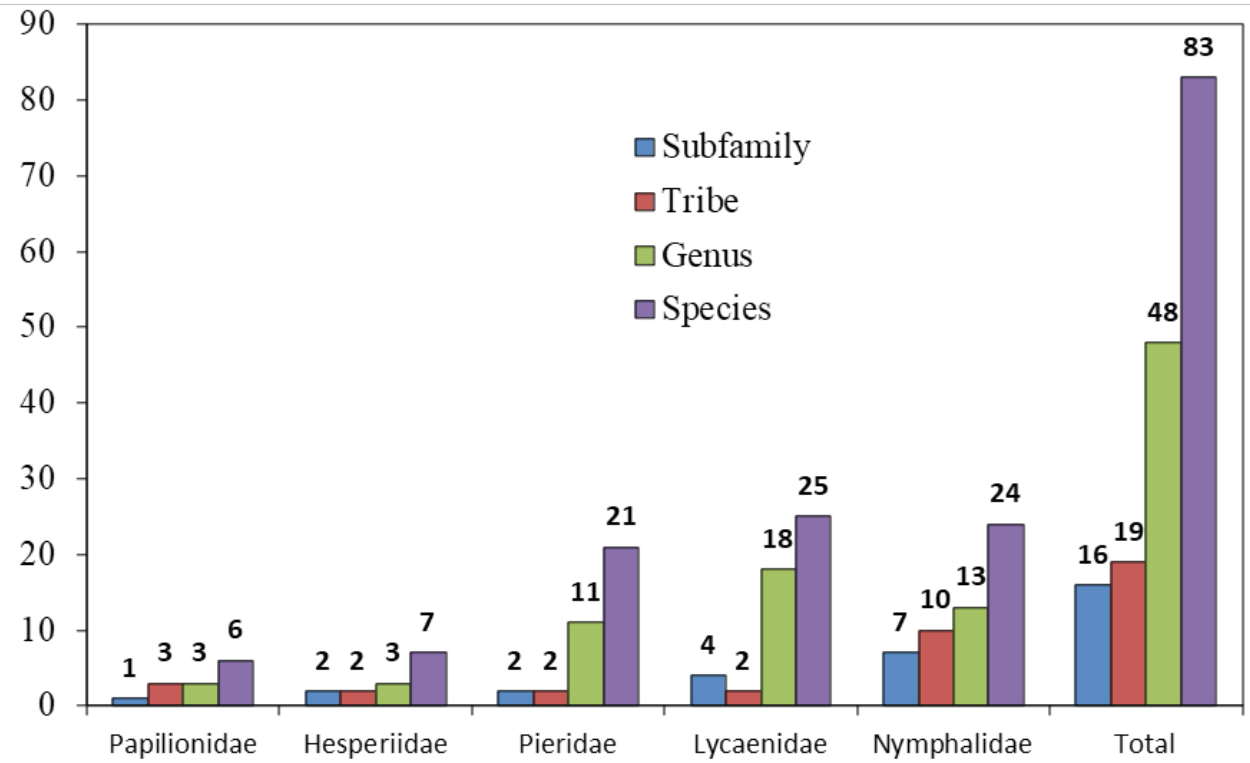


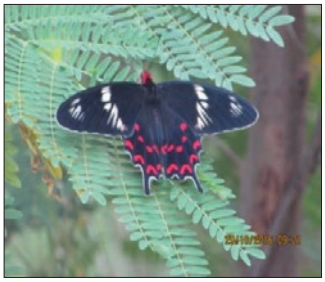
Figure 1: Total number of Subfamily, Tribe, Genus and Species recorded in each butterfly family

Table 2. Total number of Subfamily, Tribe, Genus and Species recorded in each Family

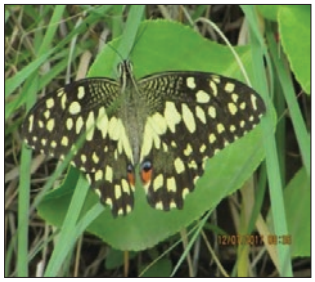
Serial number	Name of the family	Total number of Subfamily, Tribe, Genus and Species recorded in each Family			
		Subfamily	Tribe	Genus	Species
1	Papilionidae	1	3	3	6
2	Hesperiidae	2	2	3	7
3	Pieridae	2	2	11	21
4	Lycaenidae	4	2	18	25
5	Nymphalidae	7	10	13	24
	Total	**16**	**19**	**48**	**83**

BUTTERFLIES OF FAMILY PAPILIONIDAE

Pachliopta aristolochiae - Common Rose



Pachliopta hector - Crimson Rose



Papilio demoleus - Lime Butterfly

Papilio polytes - Common Mormon male

Papilio polytes - Common Mormon female

Graphium doson - Common Jay

Graphium agamemnon - Tailed Jay

BUTTERFLIES OF FAMILY HESPERIIDAE

Hasora badra- Common Awl

Hasora chromus- Common Banded Awl

*Potanthus pseudomaesa - Indian Dart

Potanthus trachala - Broad Bi –dent Dart

Pelopidas agna- Dark Branded Swift

Pelopidas manthias- Small Branded Swift

Pelopidas subochracea- Large Branded Swift

BUTTERFLIES OF FAMILY PIERIDAE

Catopsilia Pomona - Common Emigrant

Catopsilia pyranthe - Mottled Emigrant

Eurema brigitta - Small Grass Yellow

Eurema hecabe - Common Grass Yellow

Eurema laeta - Spotless Grass Yellow

Leptosia nina- Psyche

Ixias Marianne - White Orange Tip female

Ixias Marianne - White Orange Tip male

Ixias pyrene - Yellow Orange Tip

Colotis amata - Small Salmon Arab

Colotis aurora - Plain Orange Tip

Colotis etrida - Orange Tip female

Colotis danae - Crimson Tip female

Colotis danae - Crimson Tip male

Colotis fausta - Large Salmon Arab

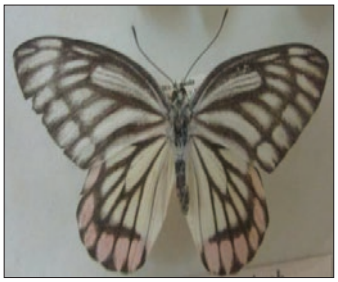
Hebomoia glaucippe - Great Orange Tip

Prioneris situ - Painted Sawtooth

Belenois aurota - Pioneer

Belenois aurota – Pioneer wing opened

Cepora nerissa - Common Gull



Delias eucharis - Common Jezabel

Pareronia valeria - Common Wanderer

BUTTERFLIES OF FAMILY LYCAENIDAE

Spindasis elima - Scarce Shot Silverline

Spindasis ictis - Common Shot Silverline

Spindasis vulcanus - Common Silverline

Deudorix epijarbas - Cornelian

Prosotas nora - Common Lineblue

Catochrysops strabo strabo – Forget Me Not wing opened

Catochrysops strabo strabo – Forget Me Not underside

Catochrysops strabo strabo - Forgetmenot

Lampides boeticus – Pea Blue underside

Lampides boeticus – Pea Blue female

Lampides boeticus – Pea Blue male

Leptotes plinius - Zebra Blue

Castalius rosimon - Common Pierrot

Tarucus extricates - Rounded Pierrot

Tarucus nara - Striped Pierrot

Zizeeria otis - Lesser Grass Blue

Zizeeria karsandra - Dark Grass Blue

Azanus jesous - African Babul Blue

Azanus ubaldus - Bright Babul Blue

Azanus uranus - Dull Babul Blue

Euchrysops cnejus- Gram Blue female

Euchrysops cnejus- Gram Blue male

Freyeria putli - Small Grass Jewel

Freyeria trochylus - Grass Jewel

Luthrodes pandava - Plains Cupid

Chilades parrhasius - Small Cupid

BUTTERFLIES OF FAMILY NYMPHALIDAE

Danaus genutia - Common Tiger

Danaus chrysippus - Plain Tiger

Hypolimnas misippus - Danaid Eggfly female

Hypolimnas misippus - Danaid Eggfly male

Tirumala limniace - Blue Tiger

Euploea core - Common crow

Euploea klugii - King Crow

Euploea Sylvester - Double – branded Crow

Melanitis leda - Common Evening Brown

Melanitis leda - Common Evening Brown underside

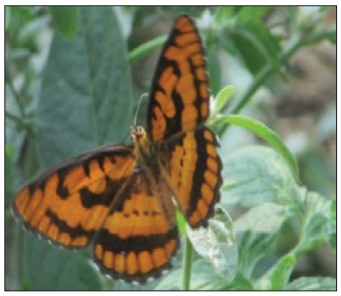
Ypthima asterope - Common Threering

Ypthima huebneri - Common Fourring

Phalanta phalantha - Common Leopard

Ariadne ariadne - Angled Castor

Ariadne merione- Common Castor



Byblia ilithyia - Joker

Vanessa cardui - Painted Lady

Junonia almana - Peacock Pansy

Junonia atlites - Grey Pansy

Junonia hierta - Yellow Pansy male

Junonia hierta - Yellow Pansy female

Junonia lemonias - Lemon Pansy

Junonia orithya - Blue Pansy wing opened

Acraea violae – Tawny Coster

Hypolimnas bolina - Great Eggfly female

Hypolimnas bolina - Great Eggfly male

Avifaunal diversity across land-use types in Delhi

Meghna Joshi and Pulak Das*

**School of Human Ecology, Ambedkar University Delhi,
Kashmere Gate, Lothian Road, Delhi – 110006**

*Email for correspondence – pulak@aud.ac.in/pulakdas.ecology@gmail.com

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Abstract: The present work examines the effects of urbanisation on bird communities by comparing the occurrence of birds along gradient of urban land-use in one of the world's most populated city, Delhi. Six land-use types; dense vegetation, waterbody, sparse vegetation, industrial area, residential area, and agricultural area were classified in which the bird diversity was studied during 2016. A total of 68 species of birds were recorded with highest (41 species) and lowest diversity (7 species) in agricultural land and residential areas respectively. During morning, the diversity (week average) was higher (4.5 to 30.5) for all classes except the agricultural land (28). Sparse vegetation showed maximum number of birds (week average) during both morning and evening (194.5 and 432.5) as compared to other classes, and residential area had least abundance of birds (week average) during both morning and evening (50 and 43). The most abundant species were *Columba livia* (in residential area-60, waterbody-119 and industrial area-79), *Pastor roseus* (in agricultural area-59 and sparse vegetation-635), and *Turdoides striata* (in dense vegetation-84). It could be observed that the open space exhibits highest positive correlation (0.599) with species richness when compared with tree cover (0.474) and impervious surface (-0.799). It is also observed that the *Corvus splendens* is one of the abundant species in residential area, industrial area, and agricultural area.

Keywords: Abundance; Bird-diversity; Gradient; Land-use; Remote sensing; Urbanization

Introduction

In the recent times, rapid urbanisation in the form of extensive land-use change has led to the conversion of green areas into built environments leading to massive transformation in the landscape, and little is known about the effects of these conversions on species, populations, communities and ecosystems (Lancaster and Rees 1979; Chace and Walsh 2004; Chapman and Reich 2007). This land development and urbanization has presented challenges to conservation biologists (Blair 1996; Mckinney 2002; Donnelly and Marzluff 2006). Birds could be seen as an essential indicator to study an ecosystem and associated ecological effects in an ecosystem because they react rapidly to any changes in the environment (Gregory et al. 2005). The species-specific requirements of birds call for an assessment of their responses to any modifications in the landscape structures. As a result, birds are often chosen as an indicator to study the habitat quality (Revaz et al. 2008). Bird traits have been used to assess the functional responses to different kinds of ecosystem change, from structure alteration (Cooch and Ricklefs 1994), to landscape fragmentation (Barbaro and van Halder 2009), land use intensity (Flynn et al. 2009), and climate changes (Jiguet et al. 2007). Cities support mostly native birds, although 31 most invasive birds are found in cities. Also, at a global level, biodiversity of bird is lost to a large extent (Lepczyk et al. 2017).

Various studies have been conducted on bird diversity along urban rural gradient, effect on bird diversity due to land-use changes and anthropogenic stresses across the world (For e.g., Melles et al. 2003). Patankar et al. (2021) observed in a review work over last couple of decades that urban bird community are dominated by generalist species and decline in specialist species, and are also showing behavioural changes such as song frequency. Otieno and Mutati (2021) observed negative effects of anthropogenic disturbance on peri-urban woodland bird assemblage and composition within the city of Nairobi, Kenya, and suggested for habitat heterogeneity through habitat zonation, widening distribution of foot-trails to increase edge-habitat density, or reducing patch isolation distances. In a study in Argentina, Filloy et al. (2019) observed that species richness was positively correlated to vegetation cover in human settlements. More urban areas supported more species as compared to the natural habitat, however this varies between arid and humid biome.

Very few studies are available on this aspect from India in general and Delhi in particular (Mukherjee and Sarma 2016; Urfi 2003; Khera et al. 2009; Turaga 2015). Dange and Kumar (2021) found 29 species of Charadriiformes in Ratlam city of Madhya Pradesh, India. Prasanth and Pandian (2020) in Parangipettai town Panchayats observed 44 species of birds. As per the study conducted by Harvey et. al in 2006, Delhi constitutes to be one of the largest urban conglomerations in India, next to Nairobi and Kenya supporting the largest diversity of birds' species. The bird list of Delhi now stands at 457 species and hence is one of the bird-rich capital cities of the world (Vyas 2019). There have been many reports of birds' species recorded in different places in the green as well as the built-up areas across Delhi (for e.g Turaga 2015). It therefore becomes important to understand the composition of avi-fauna supported by various micro-urban habitats to obtain a complete over-view of avian status across a metropolitan area like Delhi (Turaga 2015) and to understand the species abundance response to urbanization and land-use change.

In the present study the bird diversity was examined in six classes of land use types ranking from the relatively pristine sites (more natural) to highly urban areas (more managed). One locality for each class was selected. Present work aimed to understand how urbanization influenced the distribution and abundance of birds across each land-use type and hence to understand the response patterns of birds' species to different land-use types in relation to the changing habitat type.

Materials and Methods

Study site

Six main categories of land use types were identified after studying the classified satellite images, Google earth images, personal field observations, various studies on land-use patterns in Delhi (Delhi Disaster Management Plan 2014-2015; Delhi Development Authority - Master Plan 2021) and using old published studies on land-use types and bird diversity across the globe following Blair (1996), and Sokhi et al. (1989). These land-use classes were Dense vegetation, Waterbody, Sparse vegetation, Industrial area, Residential area, and Agricultural area (Figure 1). Bird diversity was examined in these six categories of land use types across Delhi ranging from

the least disturbed to the highly disturbed habitats. dense vegetation constitutes to be the natural urban forest patches of Delhi region. The urban forest patches in Delhi are one of the most thickly wooded and dense forested areas across Delhi, hence are also considered to be Delhi's green lungs. The specific site under dense vegetation which was sampled for the present work was Sanjay Van which covers an area of 789 acres. Waterbody/wetland are area which is saturated under water either permanently or seasonally such that it takes the characteristics of a distinct ecosystem. The specific site under waterbody which was covered for the present study was Jahangirpuri marshes which is presently the largest water body in Delhi. Sparse vegetation areas primarily cover the open space recreational area in the form of Gardens of Delhi. The specific site under sparse vegetation area which was covered for the study was Lodhi Garden which is a monumental garden and spreads in an area of 90 acres. The specific site under industrial area which was sampled for the study was Okhla industrial area since out of the 8 industrial complexes in Delhi, Okhla industrial area constitutes to be a major cluster of the industrial complex with 437 sheds (Planning Department 2021). Phase I and Phase II of the Okhla Industrial area which comprises of maximum cluster of industries were covered for the present work. The national capital is one of the most densely populated cities in the country with over 9000 people living in its every square kilometre, according to the latest census data (www.censusindia.gov.in). The specific site in the North East Delhi residential complex which was covered for the present work is the locality of Kardampuri in Shahdara. The Yamuna River runs through the middle of Delhi. The specific site for agriculture area which was surveyed for the present work was the Wazirabad-Jagatpur agricultural land.

Methodology

Bird sampling was done using the point count method. Ten 20 m radius plots were surveyed using global positioning system (GPS) unit at each land-use type (Figure 2). Each plot was visited for a 5 minutes observation (adapted from Blair 1996) period during morning and the evening hours for a period of two weeks during a specific day which was assigned to each land-use type. The plots were >=100 m from its nearest neighbor, within each site. As weather can influence the occurrence of some bird species (Bibby et al. 1992; Sutherland et al. 2004), working during rain and strong winds was avoided. All the species of birds identifiable by sight or song were a part of the observation in the 5 minutes wide increment up to 20m from the point. The flying individuals, such as kites or crows, which passed over the circle but did not land or forage within its perimeter were not recorded (Blair 1996). The bird identification was done with the help 'Birds of the Indian Subcontinent' by Inskipp et al. (2011) and using Olympus 8*40 DPSI binoculars and location was marked using the Garmin GPS Device. Because of the complexity of studying avian ecological variables in an urban-rural gradient, a measurable gradient of land cover proportion in different land-use type was calculated. These more objective variables are percentages of impervious surface, tree cover, and open space in each land-use type. The work was done on a Landsat image of Delhi region for the month of March for the year 2016 which had the minimum cloud cover (downloaded from https://glovis.usgs.gov/). The image was studied using false colour composite and supervised classification. Six waypoints were taken from the six land-use types across Delhi region and were geo-processed. A buffer of 1000 m was created around them and a vector layer of all the six buffer zones was used and a subset image was created and extracted from this supervised classified image of Delhi region. Of the extracted image, the area % was calculated.

Results

A total of 68 species (Table 1) of birds were recorded belonging to 38 families and 17 orders from six ecosystem types. Photographs of some selected species such as *Prinia socialis, Ploceus philippinus, Milvus migrans, Gallinula chloropus, Dicrurus macrocercus, Streptopelia decaocto, Passer domesticus, Saxicoloides fulicatus, Phalacrocorax fuscicollis, Turdoides striata, Dinopium benghalense, Microcarbo niger, Zosterops palpebrosus, Gracupica contra, Cinnyris asiaticus, Ocyceros birostris,* etc. are provided in Figure 3.

It could be observed that the species richness was maximum in agricultural land-use type (Figure 4.a) with a count of 41 species, closely followed by the dense vegetation and the sparse vegetation land-use types recording 38 and 31 species respectively. While the number of species recorded in waterbody was 23 and that in the industrial area land-use type was 14, the residential area land-use type were the lowest

(7). Similar pattern is observed in case of morning and evening species richness (Figure 4.b), except that in dense vegetation, morning species richness is slightly higher (30.5) as compared to morning value of agricultural land (28). Number of species recorded during evening is lower as compared to in the morning in all land-use type (24 and 30.5 in dense vegetation; 21.5 and 25.5 in sparse vegetation; 13.5 and 19 in waterbody; 7.5 and 10.5 in industrial area), but agricultural land (29 and 28) and residential area (4.5 each).

Pattern in number of individuals counted (Figure 5.a) in different land-use type was different from species richness pattern where in sparse vegetation, highest number of individuals were observed both in morning (194.5) and evening (432.5), and the lowest figures were in residential area both in morning (50) and evening (43). Except in agriculture and sparse vegetation morning figure was higher as compared to evening figure. Highest individual numbers per species were observed (Figure 5.b) in sparse vegetation during evening (20.4) and in residential area during morning (11). The lowest values were observed in agricultural land during morning (4.6) and dense vegetation during evening (5.5).

Species dominance per land-use type was also recorded (Figure 6). In sparse land-use type the most abundant species were *Pastor roseus* (635) followed by *Psittacula krameria* (109), *Acridotheres tristis* (103) and the least were *Prinia socialis* (1) and *Accipiter badius* (1). In dense vegetation land-use type the highest abundance was of *Turdoides striata* (84) and *Himantopus himantopus* (65), and the lowest abundance was of *Merops orientalis* and *Phoenicurus ochruros.* In Industrial area, the species which dominated were *Columba livia* (79), and *Corvus splendens* (42), while the least abundant species were *Vanellus indicus* (1) and *Halcyon smyrnensis* (1). In the agricultural area land-use type, the species which were abundant were the *Pastor roseus* (59) and *Corvus splendens* (54). The rare species (with one individual each) in the agricultural area were *Pseudibis papillosa* and *Chrysomma sinense*. In water-body, the species which showed the maximum abundance were *Columba livia* (119), and *Himantopus himantopus* (60), while *Tringa ochropus* (1), and *Saxicoloides fulicatus* (1) were least in number. In residential area land-use types, maximum abundance was seen for *Columba livia* (60), and *Corvus splendens* (59) while the *Streptopelia decaocto* (2) and *Acridotheres tristis* (4) were the least in numbers.

In terms of the land cover of different land-use types (Figure 7), impervious land was highest in residential area (86.9%) followed by industrial area (69.2%), agriculture (38.59%), and waterbody (29.05%). Land covered by pavement, colonies and people was highest in the residential area although the percentage of land covered by buildings was highest in the industrial area and it could be seen that the intensity of human use also varied between the sites, particularly in the residential area and the industrial area. The percentage of land covered by trees and shrubs was highest in the dense vegetation patch (31.02%) closely followed by the sparse vegetation patch (1.47%), and waterbody (0.11%). Open space was highest in sparse vegetation (97.35%) followed by waterbody (70.05%) and dense vegetation (64.43%), but the percentage of land covered by grasses was highest at the agricultural land.

To examine the impact of urbanisation with the help of measurable gradient, correlation was performed for avian ecological parameters with the above-mentioned variables (open space, impervious, and tree cover) (Table 2). From the correlation analysis it could be observed that total species richness was strongly negatively correlated with impervious surface ($r = -0.799$; $P < 0.05$, T test: -2.67). There was a high positive correlation between the species richness and open space ($r = 0.599$; $P < 0.05$, T test: 1.49). Correlation between tree cover and species richness was moderately strong ($r = 0.474$, T test: 1.08). Similarly, the morning and evening density was strongly negatively correlated with impervious surface (-0.62 and -0.52), and strongly positively correlated with the open space (0.504 and 0.653). Tree cover either showed moderate (morning) (0.467) or weak correlation (evening) (-0.058). Shannon diversity index showed strong negative correlation with impervious surface for morning (-0.778), and strong positive correlation with tree cover (both morning and evening) and open space (only morning) (0.566).

Discussion

In the present study we did not record *Schoenicola striatus* (Bristled Grassbird) which is considered to be a key species of most conservation concern of Delhi, by SoIB (2020). It could be observed that the species richness of birds is lowest in the residential area where human population is expected to be highest.

This species decline along the gradient of the most populated residential suburb is possibly because of the increasing urban development. A similar pattern could also be observed in the industrial area land-use type which observed the second lowest species richness (14 species) after the residential area land-use types (7 species). Beaugeard et al. (2021) observed in a study in a small French city that the bird species richness was positively impacted by green areas, and particularly green corridors, which supported rare species in cities. The abundance pattern of some species dominated particular land-use types. *Columba livia* and *Corvus splendens* for example are the most abundant species in residential areas. Ferman et al. (2010) observed that *Columba livia var.* are more densely found in the urban areas as compared with suburbs of Germany. Fernández-Maldonado et al. (2017) also observed that nest abundance of *Columba livia* increased in the city centre of San Juan city, Argentina. Wilson et al. (2015) observed that *Corvus splendens* is more abundant in urban areas of Malaysia. They attributed availability of food waste to be one of the reasons. Fraser et al. (2015) while discussing *Corvus splendens* as a pest in New Zealand mentioned likelihood of significant negative impact of the species. A pattern could be seen as mentioned above, to emerge in response to the individual bird species to urbanisation and this variation has sensitively resulted in assemblages specific to the degree of disturbance along the gradient of urbanization. Śliż et al. (2021) in a study in Krakow, Poland observed that exurban area has the highest abundance of birds. Aronson et al. (2014) observed that birds like *Columba livia* are cosmopolitan across the globe. They also argued that the reasons for loss of density of species in cities are landcover change and age of the city. Yang et al. (2020) observed in Nanjing, China, that larger distance from city centres are positive predictors of bird diversity. Kurucz et al. (2021) in a study in Hungary observed that bird diversity does not change with urban gradient. They however saw effect of urban gradient on abundance of species and mentioned the reason to be present of certain species known as synanthropic (which lives close to people) for example *Columba* sp.

Urban-rural gradient studies show that the number of non-native species increases towards centres of urbanisation while the number of native species decreases. It could also be observed from the data that the non-native species or the urban-adapters like *Streptopelia decaocto*, and *Pycnonotus cafer* increased towards the centre of urbanization (in the residential area land-use type) and the number of native species or the urban avoiders like *Phylloscopus collybita* disappeared in this gradient. The pattern could also be explained after observing the dominance of select birds which were high in number like *Acridotheres tristis, Columba livia,* and *Corvus splendens* in almost all the land-use types This pattern could also be explained using the concept of invasive or non-invasive species. While the exact classification of a species as invasive or non-invasive or native or non-native can be a bit tricky in urban context. Not all non-native birds are therefore naturally invasive, many of them can adapt to new niches in different ecosystems without harmful effects like the case of urban adapters (which are able to adapt to the city environment) and urban exploiters which are totally dependent on human resources. These species are able to thrive themselves in the matrix of human land-use of suburban landscapes from where they are also able to get the food and shelter which helps them to survive and adapt to the suburban environmental conditions.

Muñoz-Pedreros (2020) in a study in Chile observed that birds in general avoid impervious surfaces and prefer green spaces with nearby water and large parks. They also observed that some birds such as *Passer domesticus* and *Columba livia* dominated the study area along with some others species. Carvajal-Castro et al. (2019) observed in Armenia, Columbia that diversity of birds in urban areas was significantly lower than rural areas. They also observed impervious areas and noise to be the major cause of decline in birds with cities. Korányi et al. (2021) used point count method for bird diversity in a German city and taking impervious cover as a measure of urbanisation, observed that increasing urbanisation had no effect on species richness, functional traits or community composition of birds. They however observed that green space type had an effect on species richness. Parks for example have higher species richness.

Conclusion

We conclude that avian diversity within city differs between land-use types that exhibit a gradient from more natural (dense and sparse vegetation) to more managed (residential and industrial) ecosystems. In

general, species diversity also varies between morning and evening time; former having high diversity, except in agricultural area. It is also observed that the imperviousness of soil has a significant negative impact on the species richness. It is further observed that species such as *Corvus splendens* are one of the dominant species in more managed ecosystems such as residential, industrial and agricultural.

Funding

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Table 1. List of birds observed in the study

S. No	Species	Common name	S. No.	Species	Common name
1	*Prinia socialis*	Ashy Prinia	35	*Turdoides malcolmi*	Large grey Babbler
2	*Eudynamys scolopaceus*	Asian Koel	36	*Dinopium benghalense*	Black-rumped Flameback
3	*Acridotheres ginginianus*	Bank Myna	37	*Sylvia curruca*	Lesser Whitethroat
4	*Psilopogon sp.*	-	38	*Microcarbo niger*	Little Cormorant
5	*Ploceus philippinus*	Baya Weaver	39	*Egretta garzetta*	Little Egret
6	*Ploceus benghalensis*	Black-breasted Weaver	40	*Tachybaptus ruficollis*	Little Grebe
7	*Dicrurus macrocercus*	Black Drongo	41	*Copsychus saularis*	Oriental Magpie-Robin
8	*Chroicocephalus ridibundus*	Black-headed Gull	42	*Zosterops palpebrosus*	Indian White-eye
9	*Milvus migrans*	Black Kite	43	*Ichthyaetus ichthyaetus*	Pallas's Gull
10	*Phoenicurus ochruros*	Black Redstart	44	*Pavo cristatus*	Peafowl
11	*Himantopus himantopus*	Black-winged Stilt	45	*Saxicola caprata*	Pied Bush Chat
12	*Metopidius indicus*	Bronze-winged Jacana	46	*Gracupica contra*	Pied Myna
13	*Psilopogon zeylanicus*	Brown-headed Barbet	47	*Ardeola grayii*	Pond Heron
14	*Bubulcus ibis*	Cattle Egret	48	*Ardea purpurea*	Purple Heron
15	*Motacilla citreola*	Citrine Wagtail	49	*Cinnyris asiaticus*	Purple Sunbird
16	*Phylloscopus collybita*	Common Chiffchaff	50	*Streptopelia tranquebarica*	Red Collared Dove
17	*Gallinula chloropus*	Common Moorhen	51	*Pseudibis papillosa*	Red Naped-Ibis
18	*Acridotheres tristis*	Common Myna	52	*Pycnonotus cafer*	Red-Vented-Bulbul
19	*Actitis hypoleucos*	Common Sandpiper	53	*Vanellus indicus*	Red-Wattled Lapwing
20	*Saxicola maurus*	Common Stonechat	54	*Pycnonotus jocosus*	Red-Whiskered Bulbul
21	*Psilopogon haemacephalus*	Coppersmith Barbet	55	*Columba livia*	Rock Pigeon
22	*Streptopelia decaocto*	Eurasian collared Dove	56	*Psittacula krameri*	Rose-Ringed Parakeet
23	*Anserinae*	Geese	57	*Pastor roseus*	Rosy Starling
24	*Merops orientalis*	Green Bee-eater	58	*Dendrocitta vagabunda*	Rufous Treepie
25	*Tringa ochropus*	Green Sandpiper	59	*Accipiter badius*	Shikra
26	*Francolinus pondicerianus*	Grey Francolin	60	*Euodice malabarica*	Indian Silverbill
27	*Ocyceros birostris*	Indian Grey Hornbill	61	*Anas poecilorhyncha*	Indian Spot-Billed Duck
28	*Motacilla cinerea*	Grey Wagtail	62	*Athene brama*	Spotted Owlet
29	*Corvus splendens*	House Crow	63	*Ploceus manyar*	Streaked Weaver
30	*Passer domesticus*	House Sparrow	64	*Halcyon smyrnensis*	White-throated Kingfisher
31	*Phalacrocorax fuscicollis*	Indian Cormorant	65	*Motacilla alba*	White Wagtail
32	*Saxicoloides fulicatus*	Indian Robin	66	*Tringa glareola*	Wood Sandpiper
33	*Ardea intermedia*	Intermediate Egret	67	*Chrysomma sinense*	Yellow-eyed Babbler
34	*Turdoides striata*	Jungle Babbler	68	*Treron phoenicopterus*	Yellow-footed Green Pigeon

Table 2. Correlation between three land-use variables and ecological parameters

	Coefficient of correlation (r)				
	Species richness	*Density*		*Shannon-wiener diversity*	
		Morning	*Evening*	*Morning*	*Evening*
Impervious	-0.799	-0.62	-0.572	-0.778	-0.359
Tree cover	0.474	0.467	-0.058	0.515	0.522
Open space	0.599	0.504	0.653	0.566	0.055

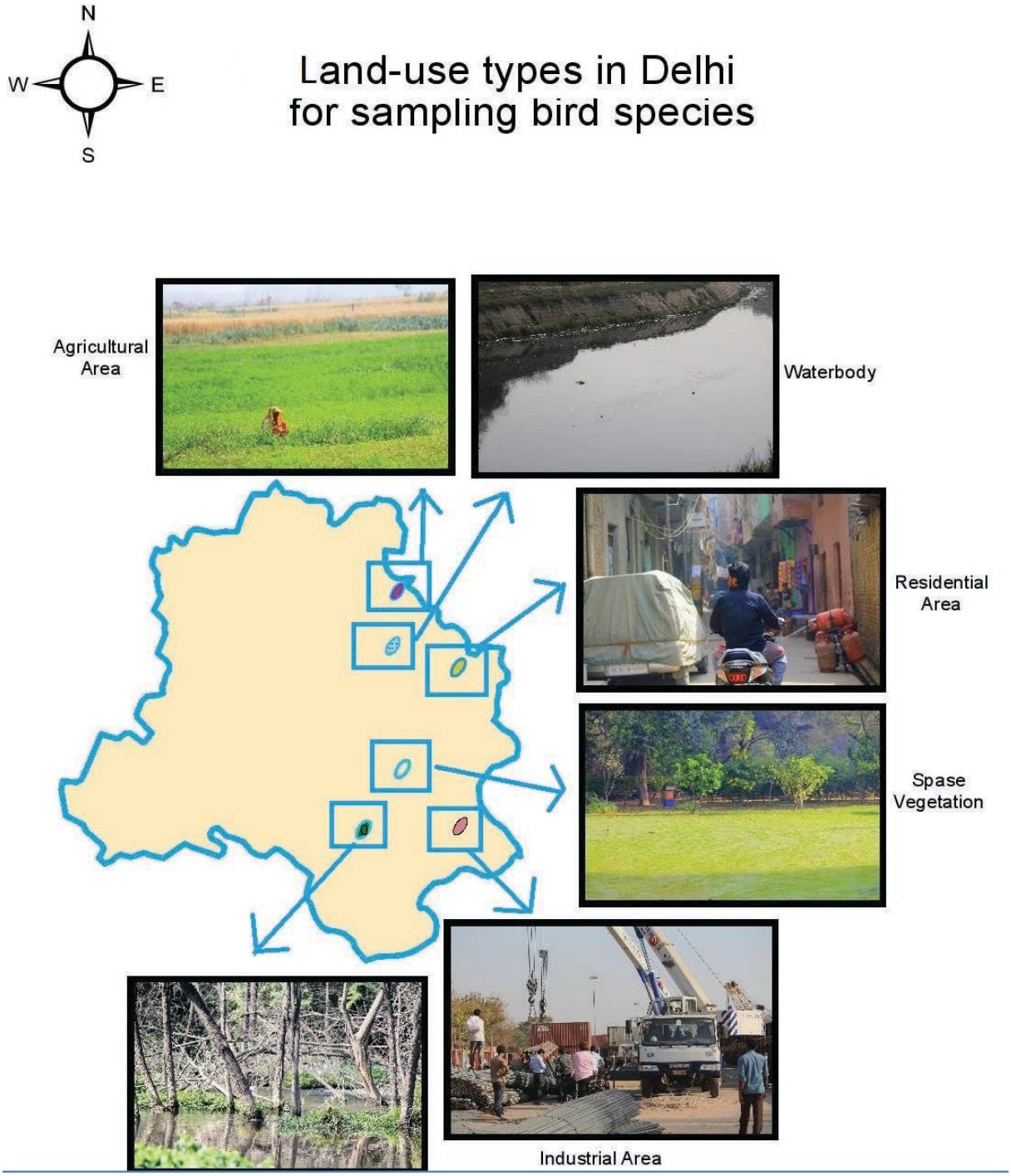


Figure 1. Study sites in Delhi

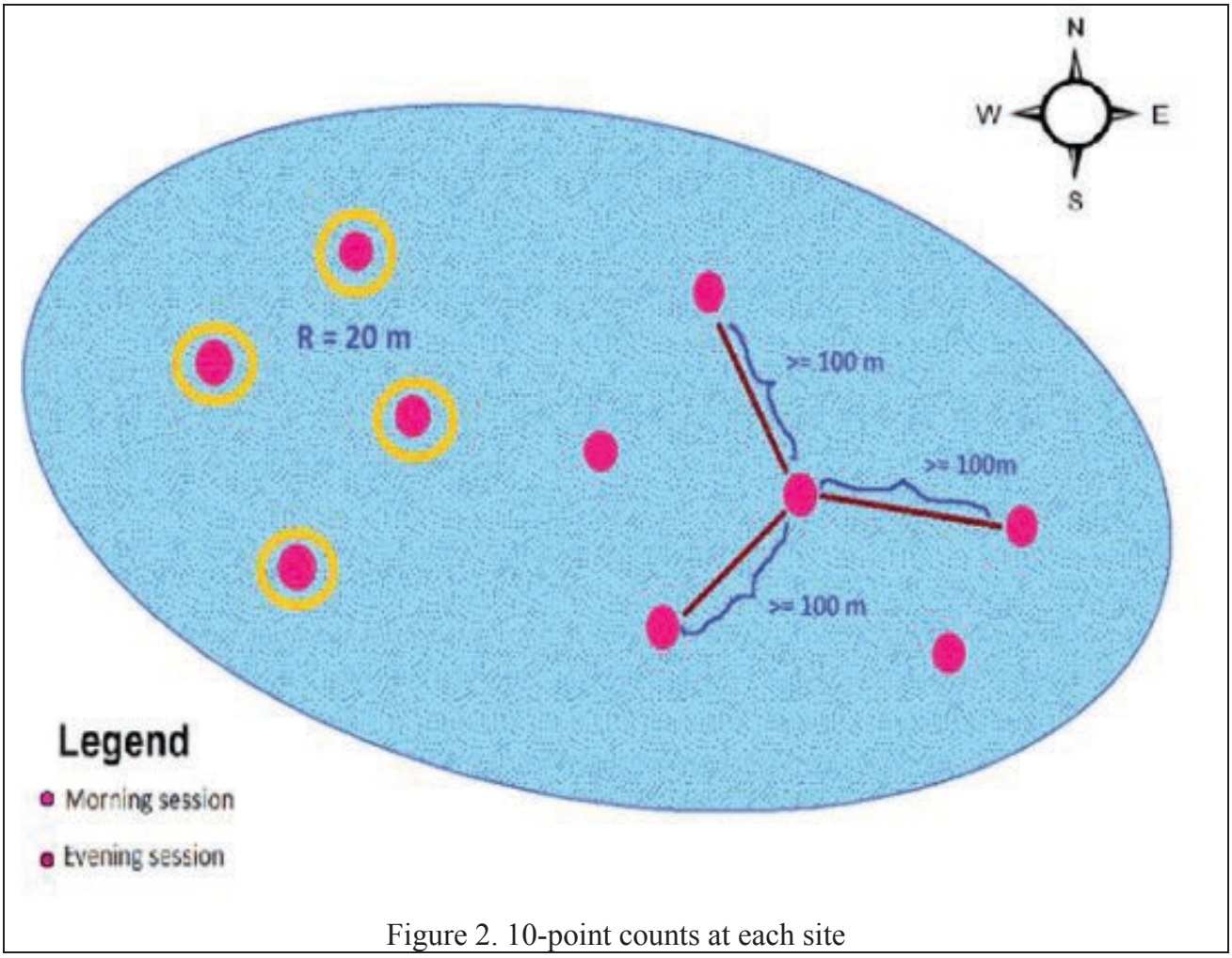
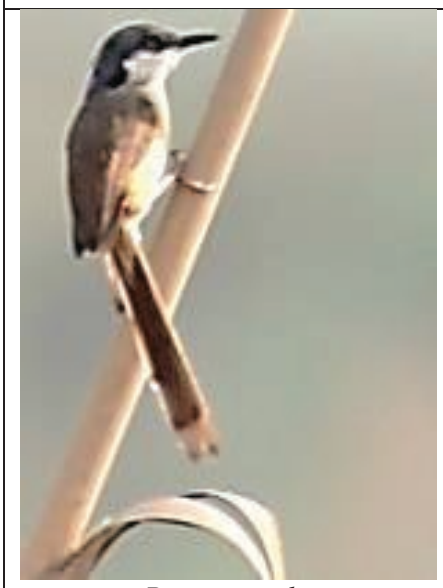


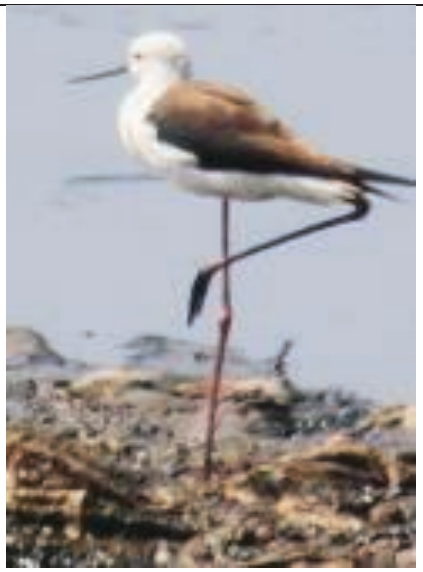
Figure 2. 10-point counts at each site



Prinia socialis

Ploceus philippinus

Milvus migrans



Himantopus himantopus

Gallinula chloropus

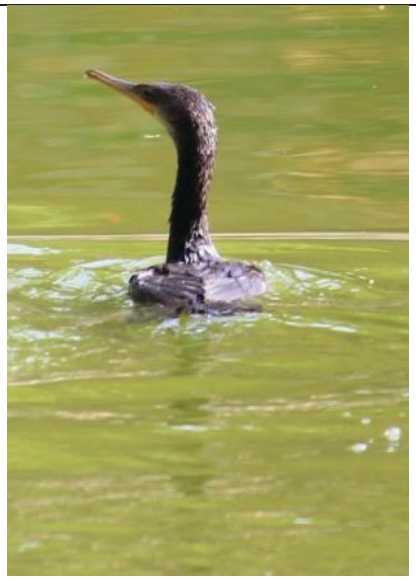
Dicrurus macrocercus

Streptopelia decaocto

Passer domesticus

Corvus splendens

Saxicoloides fulicatus



Phalacrocorax fuscicollis

Turdoides striata

Dinopium benghalense

Microcarbo niger

Zosterops palpebrosus

Egretta garzetta

Gracupica contra

Cinnyris asiaticus

Pseudibis papillosa

Vanellus indicus

Pycnonotus jocosus

Psittacula krameri

Copsychus saularis

Ardea purpurea

Ocyceros birostris

Motacilla cinerea

Tachybaptus ruficollis

Pavo cristatus

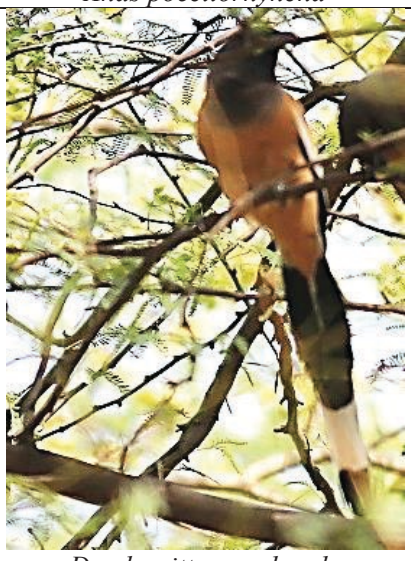
Streptopelia tranquebarica

Lonchura cantans

Anas poecilorhyncha

Athene brama

Halcyon smyrnensis



Dendrocitta vagabunda

Chrysomma sinense

Merops orientalis

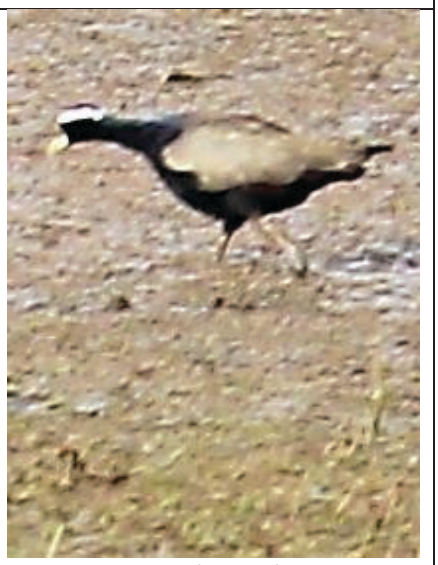
Acridotheres ginginianus

Motacilla alba

Sylvia curruca

Phoenicurus ochruros

Eudynamys scolopaceus



Metopidius indicus

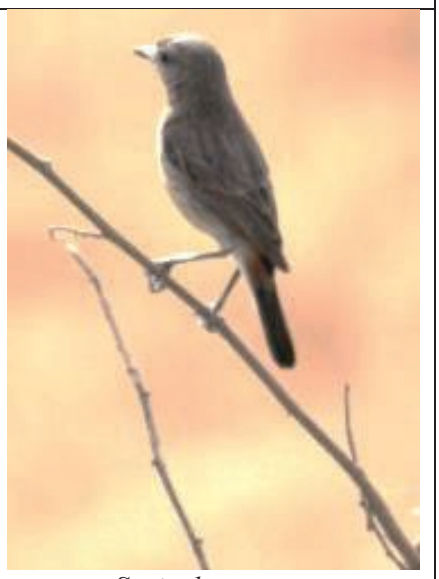
Chroicocephalus ridibundus

Bubulcus ibis

Motacilla citreola

Acridotheres tristis

Tringa ochropus



Saxicola caprata

Ardeola

Columba livia

Pastor roseus

Treron phoenicoptera

Phylloscopus collybita

Tringa glareola

Figure 3. Some selected species captured during the field visits by the first author

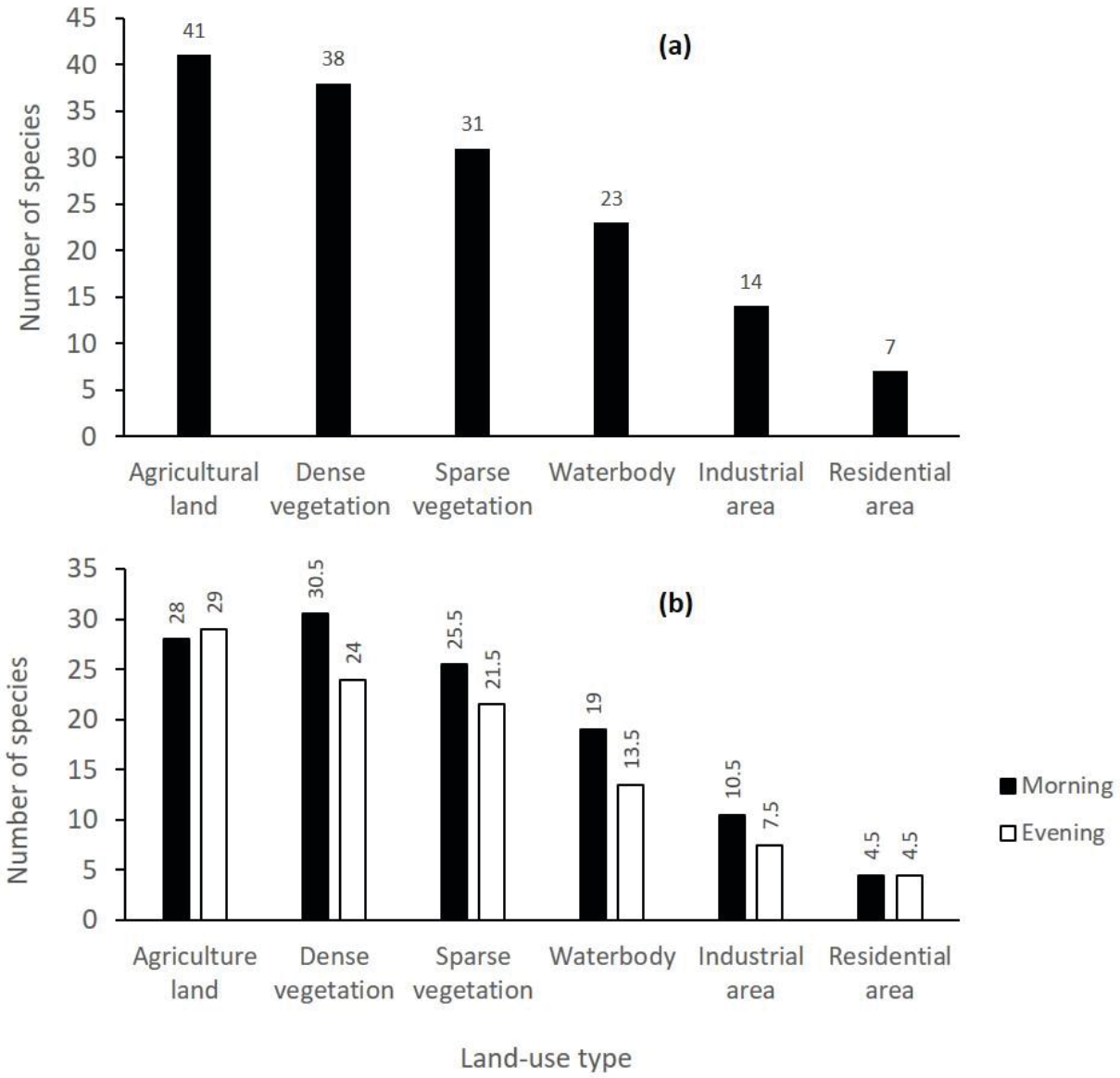


Figure 4. Species of Birds across six land-use types; a) Total, b) Week average of morning and evening

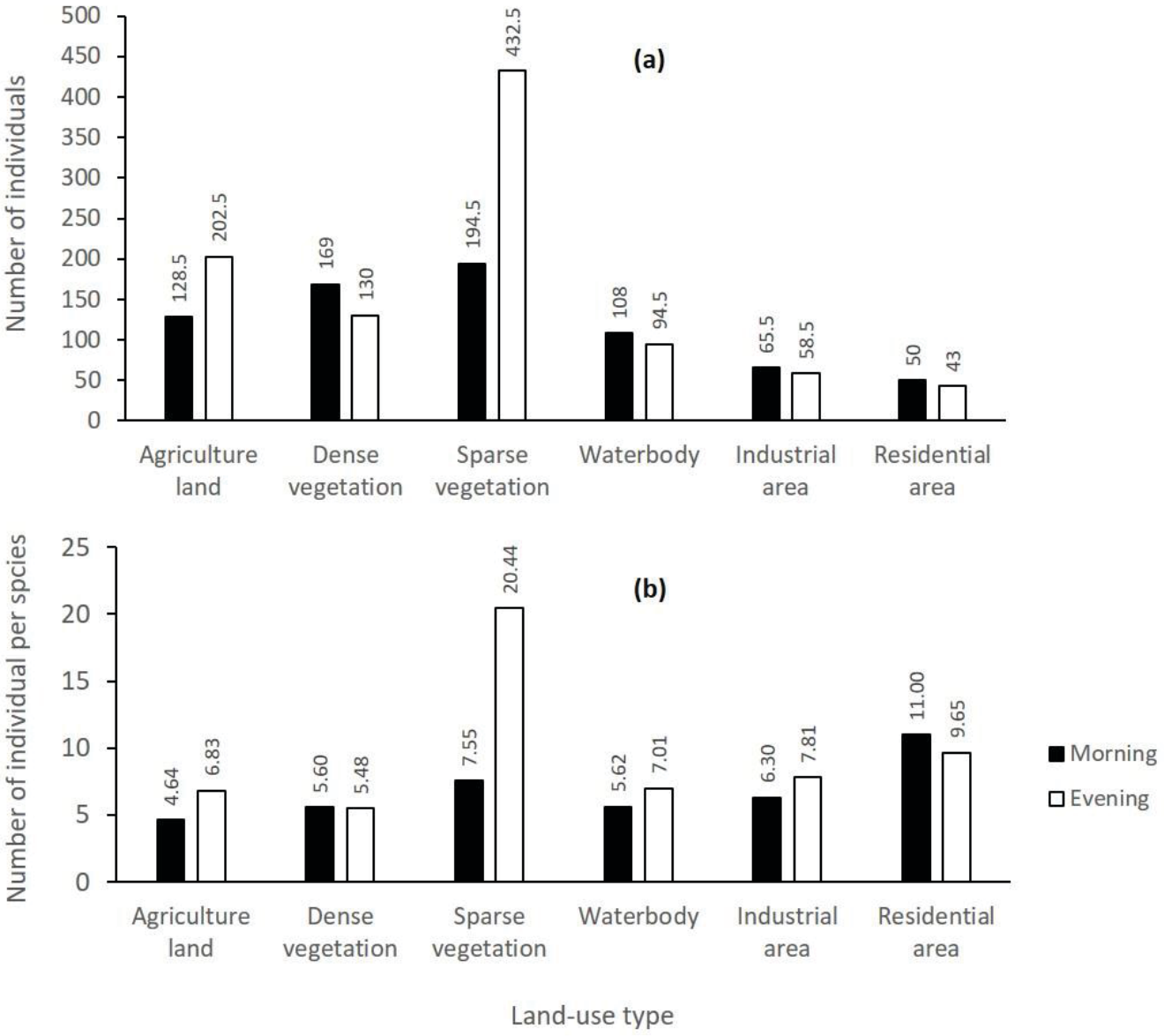


Figure 5. Week average of; a) Number of individuals, b) Number of individuals per species, across land-use types

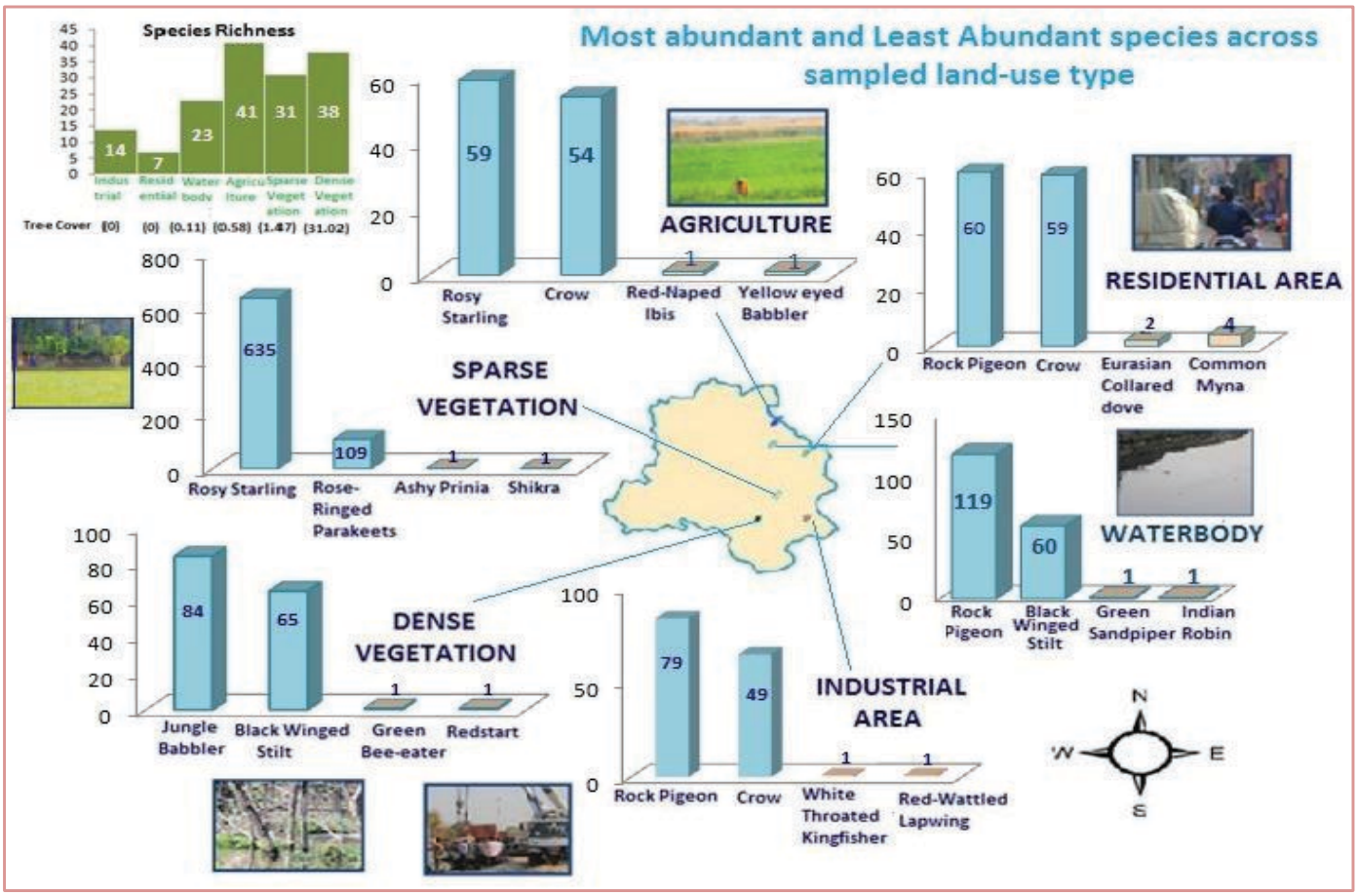


Figure 6. Most abundant and Least abundant species across sampled land-use type

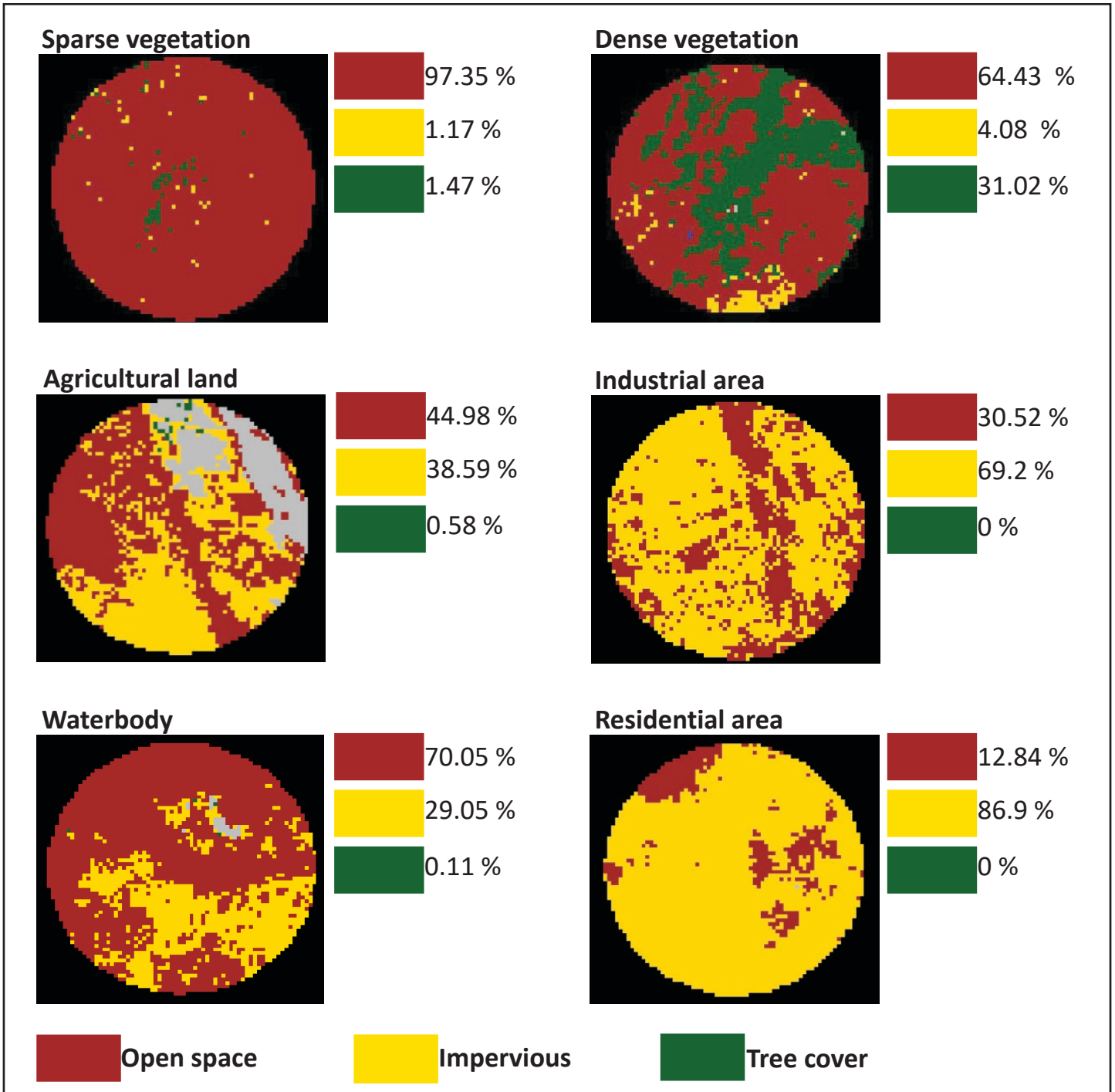


Figure 7. Percentage of three variables characterising urbanisation in different land-use types

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Checklist of Birds of Malwadi No. 1, Indapur Tahsil, Pune District, Maharashtra, India

Rajendra V. Salunkhe*[1], Sambhaji H. Bhosale[2], Sanjay K. Gaikwad[3]

1. Department of Zoology, Arts, Science and Commerce College, Indapur, Dist. Pune, Maharashtra, India.
2. Department of Zoology, Shankarrao Mohite Mahavidyalaya, Akluj, Dist. Solapur, Maharashtra, India.
3. Department of Cell and Molecular Biology, Rajiv Gandhi Institute of IT and Biotechnology, Bharati Vidyapeeth Deemed University, Pune-411046, Maharashtra, India.

Email: rvsalunkhe4444@gmail.com

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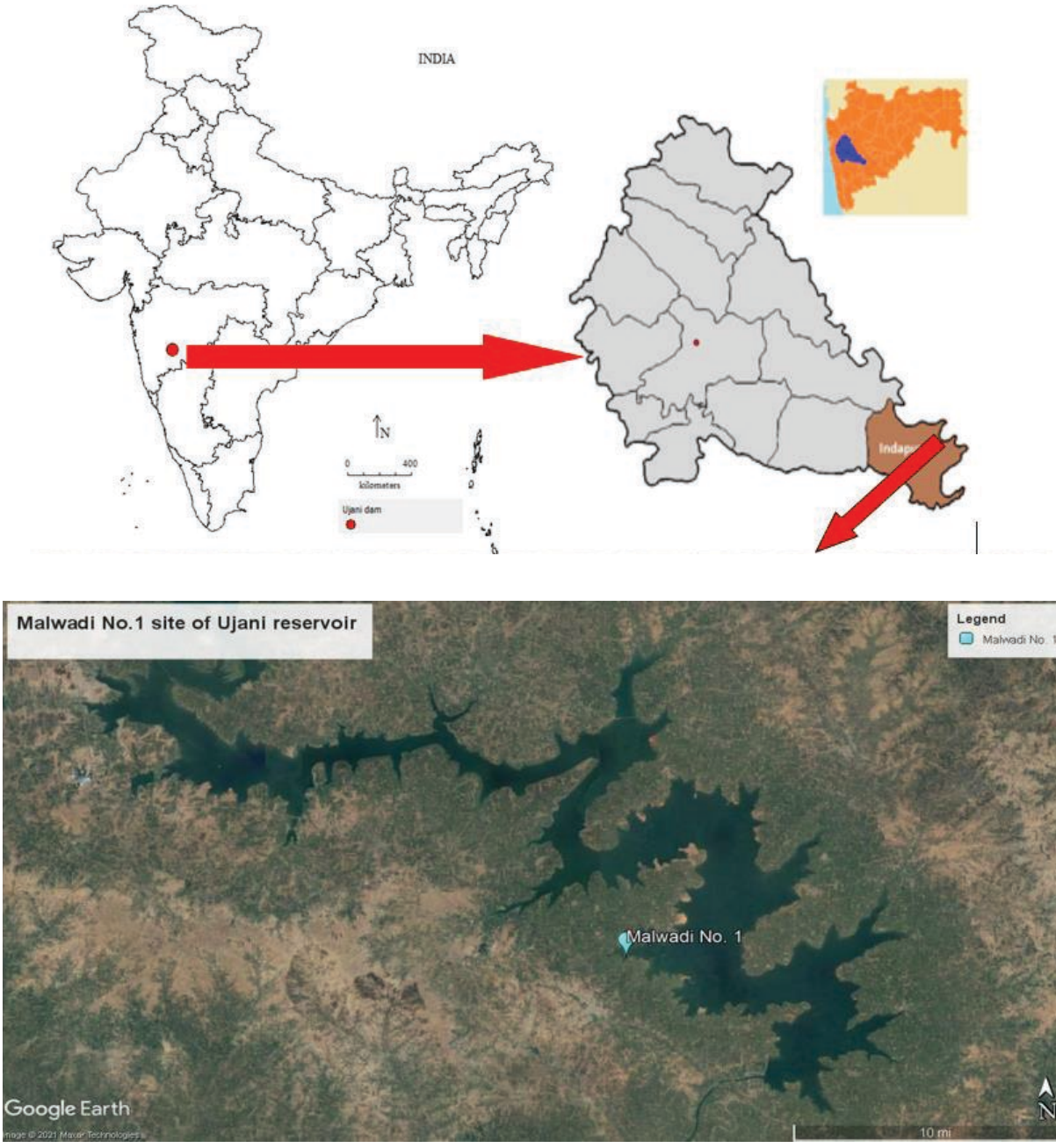
Abstract

The present study conducted at Malwadi No. 1, Tahsil -Indapur, Maharashtra on the bank of the perennial Bhima river recorded a total of 154 bird species belonging to 60 families including 107 residents, 46 migrants and one vagrant species in various habitats. Rock Bush Quail (*Perdicula argoondah*) and White-spotted Fantail (*Rhipidura albogularis*) are endemic residents.

Keywords: Birds, Resident, Migratory, Local Migratory, Near threatened.

Introduction

The Indian subcontinent, a part of the oriental region is rich in biodiversity. Out of more than 9000 birds of the world, the Indian subcontinent consists about 1300 species or over 13% of the world's birds (Grimmett *et al*., 1998). Natural and manmade fresh water wetlands provide numerous ecological services. They provide habitat to aquatic flora and fauna including birds (Natural environment policy, 2006). The avifauna in turn play a crucial role as scavengers, pollinators, seed dispersal agents and predators of insect pest (Padmavati *et al*., 2010). Bhima River is the tributary of Krishna river system with Ujani dam constructed in the year 1981 on Bhima River (Ranjit *et al*., 2020). Bhima River has been enriched with several local and migratory wetland birds. Since no previous study was available, authors conducted the baseline survey of the region to prepare a checklist of birds which could be helpful to develop conservation policies.



Photograph 1. Location of Malwadi No.1 and Ujani reservoirTable 1:

Materials and Methods

Village Malwadi No.1 located at the bank of Bhima river is at 493 meters above the sea level (18°08'27"N; 75°02'"E). Field study and observations of different bird species were carried out with the help of binoculars (Olympus 10X50). Avian photographs were taken using Nikon 3200, and birds were identified and their status was determined using published keys. The study was conducted during June 2016 to May 2020. Field observations were from all the three seasons; monsoon, winter and summer. Studies were conducted twice in a week in morning from 06.30 to 10.00 hours, evening 15.00 to 18.00 hours and at night during 20.00 to 23.00 hours for nocturnal birds. The identification of fauna was done with standard field guides for birds (Salim Ali, 2002; Pande, *et al*. 2003; Pande et al. 2011; Kukdolkar, 2011 and Pande, et al. 2016). Species richness was calculated by recording the number of birds observed in each habitat of the study area. The birds were classified as Resident (R), Migratory (M) and Local Migrants (LM), and the IUCN status and endemism (E) based on bird life international (2017) and Pande, et al. (2016).

Results and Discussions

The present checklist of birds from Malwadi No. 1 is of 154 bird species from 60 families and 118 genera. There were 3 near threatened, one vulnerable and one endemic species. 107 were resident, 40 are migratory and 7 local are migrant species. Food habits of these birds are herbivorous, carnivorous, and omnivorous in diverse habitats. According to Kumbhar and Mhaske (2021) distribution of birds among various sites has shown considerable variation and this variation might be due the availability of food, level of human interference and also level of water.

Table 1: Bird diversity at Malwadi No.1 recorded during the study

Sr. No.	Family	Common Name	Scientific Name	Habitat	Status
1	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	FW	R
2	Phalacrocoracidae	Little Cormorant	*Phalacrocorax niger*	FW	R
3	Ardeidae	Little Egret	*Egretta garzetta*	FW	R
4		Great Egret	*Ardea alba*	FW	R
5		Intermediate egret	*Mesophoyx intermedia*	FW	R
6		Western Cattle Egret	*Bubulcus coromandus*	CL	R
7		Grey Heron	*Ardea cinerea*	FW	R
8		Purple Heron	*Ardea purpurea*	M	R
9		Indian Pond Heron	*Ardeola grayii*	FW	R
10	Ciconiidea	Asian Openbill	*Anastomus oscitanus*	M	R
11		Wolly-necked Stork	*Ciconia episcopus*	M	R
12		Painted Stork	*Mycteria leucocephala*	M	LM,NT
13	Threskiornithidae	Glossy Ibis	*Plegadis falcinellus*	M	LM
14		Black-headed Ibis	*Therskiornis melanocephalus*	M	R,NT
15		Red-naped Ibis	*Pseudibis papillosa*	M	R
16		Eurasian Spoonbill	*Platalea leucorodia*	M	R
17	Phoenicopteridae	Greater Flamingo	*Phoenicopterus ruber*	FW	LM
18	Anatidae	Bar-headed Goose	*Anser indicus*	M	M
19		Brahminy Shelduck	*Tadorna ferruginea*	FW	M
20		Common Teal	*Anas crecca*	FW	M
21		Garganey	*Anas querquedula*	FW	M
22		Gadwal	*Anas strepera*	FW	M
23		Northern Shoveler	*Anas clypeata*	FW	M
24		Northern Pintail	*Anas acuta*	FW	M
25		Indian Spot-billed Duck	*Anas poecilorhyncha*	FW	R
26	Accipitridae	Black-winged Kite	*Elanus caeruleus*	CL	R
27		Brahminy Kite	*Haliastur indus*	FW	R
28		Black Kite	*Milvus migrans*	HH	R
29		Shikra	*Accipiter badius*	TF	R
30		Short-toed Snake-Eagle	*Circaetus gallicus*	S	R
31		Bonelli's Eagle	*Aquila fasciata*	S	R
32		Greater Spotted Eagle	*Aquila clanga*	S	M
33		Steppe Eagle	*Aquila nipalensis*	GL	M
34		Western Marsh-Harrier	*Circus aeruginosus*	M	M

35	Pandionidae	Osprey	*Pandion haliaetus*	FW	M
36	Phasianidae	Grey Francolin	*Francolinus pondicerianus*	CL	R
37		Rock Bush-Quail	*Perdicula argoondah*	S	R,E
38		Indian Peafowl	*Pavo cristatus*	CL	R
39	Turnicidae	Barred Buttonquail	*Turnix suscitator*	CL	R
40	Rallidae	White-breasted Waterhen	*Amauronis phoenicurus*	M	R
41		Common Moorhen	*Gallinula chloropus*	M	R
42		Eurasian Coot	*Fulica atra*	FW	R
43	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	PW	LM
44	Burhinidae	Great Thick-knee	*Esacus recurviostris*	M	R
45	Glareolidae	Small Pratincole	*Glareola lacteal*	M	R
46	Laridae	Pallas's Gull	*Larus ichthyaetus*	FW	M
47		Brown-headed Gull	*Larus brunnicephalus*	FW	M
48	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	HH	R
49		Common Ringed Plover	*Charadrius hiaticula*	BR	M
50		Little Ringed Plover	*Charadrius dubius*	BR	R
51		Kentish Plover	*Charadrius alexandrines*	BR	LM
52	Scolopacidae	Western Black-tailed Godwit	*Limosa limosa*	M	M,NT
53		Wood snipe	*Gallinago nemoricola*	M	V,Vu
54		Wood Sandpiper	*Tringa glareola*	M	M
55		Green Sandpiper	*Tringa ochropus*	M	M
56		Common Sandpiper	*Actitis hypoleucos*	M	M
57		Marsh Sandpiper	*Tringa stagnatilis*	M	M
58		Common Redshank	*Tringa totanus*	M	M
59		Spotted Redshank	*Tringa erythropus*	M	M
60		Little Stint	*Calidris minuta*	BR	M
61	Sternidae	Little Tern	*Sterna albifrons*	FW	R
62		River Tern	*Sterna aurantia*	FW	R
63		Saunder's Tern	*Sterna saundersi*	FW	M
64	Pteroclidae	Chestnut-bellied Sandgrouse	*Pterocles exustus*	S	R
65		Painted Sandgrouse	*Pterocles indicus*	S	R
66	Columbidae	Blue Rock Pigeon	*Columba livia*	HH	R
67		Little Brown Dove	*Streptopelia senegalensis*	EW	R
68		Eurasian Collared-Dove	*Streptopelia decaocta*	TF	R
69		Red Collared-Dove	*Streptopelia tranquebarica*	TF	R
70	Psittacidae	Rose-ringed Parakeet	*Psittacula krameri*	TF	R
71	Cuculidae	Grey-bellied Cuckoo	*Cacomantis passerines*	TF	R
72		Asian Koel	*Eudynamys scolopaceus*	TF	R

73		Common Cuckoo	*Cuculus canorus*	TF	M
74		Common Hawk-Cuckoo	*Hierococcyx varius*	CL	R
75		Blue-faced Malkoha	*Phaenicophaeus viridirostris*	TF	R
76		Greater Coucal	*Centropus sinensis*	TF	R
77	Strigidae	Spotted Owlet	*Athene brama*	HH	R
78	Tytonidae	Common Barn-Owl	*Tyto alba*	HH	R
79	Carimulgidae	Jerdon's Nightjar	*Caprimulgus atripennis*	TF	R
80	Apodidae	House Swift	*Apus nipalensis*	FCL	R
81	Coraciidae	Indian Roller	*Corocias benghalensis*	TF	LM
82	Upupidae	Eurasian Hoopoe	*Upupa epops*	TF	R
83	Dacelonidae	White-throated Kingfisher	*Halcyon smyrnensis*	CL	R
84	Cerylidae	Pied Kingfisher	*Ceryle rudis*	FW	R
85	Alcedinidae	Common Kingfisher	*Alcedo atthis*	FW	R
86	Meropidae	Green Bee-eater	*Merops orientalis*	CL	R
87		Blue-tailed Bee-eater	*Merops philippinus*	FW	M
88	Bucerotidae	Indian Grey Hornbill	*Ocyceros birostris*	TF	R
89	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	TF	R
90	Picidae	Eurasian Wryneck	*Jynx torquilla*	S	M
91	Alaudidae	Singing Bushlark	*Mirafra cantillans*	S	R
92		Indian Bushlark	*Mirafra erythroptera*	S	R
93		Ashy-crowned Finch-Lark	*Eremopterix griseus*	S	R
94		Rufous-tailed Lark	*Ammomanes phoenicura*	S	R
95	Hirundinidae	Dusky Crag-Martin	*Ptyonoprogne concolor*	HH	R
96		Streak-throated Swallow	*Hirundo fluvicola*	FW	R
97		Barn Swallow	*Hirundo rustica*	EW	M
98		Red-rumped Swallow	*Cecropis daurica*	EW	R
99		Wire-tailed Swallow	*Hirundo smithii*	EW	R
100	Motacillidae	Western Yellow Wagtail	*Motacilla flava*	GL	M
101		Grey Wagtail	*Motacilla cinerea*	GL	M
102		White Wagtail	*Motacilla alba*	M	M
103		White-browed Wagtail	*Motacilla madaraspatensis*	M	R
104		Paddyfeild Pipit	*Anthus rufulus*	GL	R
105		Long-billed Pipit	*Anthus similis*	GL	M
106	Campephagidae	Small Minivet	*Percrocotus cinnamomeus*	TF	R
107		White-bellied Minivet	*Pericrocotus erythropygius*	TF	R
108	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	HH	R
109	Aegithinidae	Common Lora	*Aegithina tiphia*	TF	R
110	Laniidae	Long-tailed Shrike	*Lanius schach*	S	R
111		Southern Grey Shrike	*Lamias meridionalis*	S	R

112		Bay-backed Shrike	*Lanius vittatus*	S	R
113		Red-backed Shrike	*Lanius collurio*	S	M
114	Monarchidae	Asian Paradise-Flycatcher	*Terpsiphone paradise*	TF	R
115	Rhipiduridae	White-browed Fantail	*Rhipidura aureola*	TF	R
116		White-throated Fantail	*Rhipidura albogularis*	TF	ER
117	Muscicapidae	Bluethroat	*Luscinia svecica*	CL	M
118		Oriental Magpie-Robin	*Copsychus saularis*	RF	R
119		Indian Robin	*Saxicoloides fulicatus*	RF	R
120		Pied Bushchat	*Saxicola caprata*	CL	LM
121		Common Stonechat	*Saxicola maurus*	CL	M
122	Sylviidae	Yellow-eyed Babbler	*Crysommas inense*	TF	R
123		Common Tailorbird	*Orthotomus sutorius*	TF	R
124		Blyth's Reed-Warbler	*Acrocephalus dumetorum*	M	M
125		Lesser Whitethroat	*Sylvia curruca*	TF	M
126		Indian Great-Reed Warbler	*Acrocephalus stentorius*	M	R
127		Paddyfield Warbler	*Acrocephaus Agricola*	M	M
128		Sulphur-bellied Warbler	*Phylloscopus griseolus*	TF	M
129		Tickell's Leaf-Warbler	*Phylloscopus affinis*	TF	M
130		Tytler's Leaf-Warbler	*Phylloscopus tytleri*	TF	M
131	Timaliidae	Large Grey Babbler	*Turdoides malcolmi*	RF	R
132	Cisticolidae	Zitting Cisticola	*Cisticola juncidis*	CL	R
133		Ashy Prinia	*Prinia socialis*	TF	R
134		Grey-breasted Prinia	*Prinia hodgsonii*	TF	R
135		Plain Prinia	*Prinia inornata*	TF	R
136	Paridae	Great Tit	*Parus cinereus*	TF	R
137	Dicaeidae	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	TF	R
138	Zosteropidae	Oriental White-eye	*Zosterops palpebrosus*	TF	R
139	Nectariniidae	Purple-rumped Sunbird	*Nectarinia zeylonica*	TF	R
140		Purple Sunbird	*Nectarinia asiatica*	TF	R
141	Estrildidae	Red Avadavat	*Amandava amandava*	CL	R
142		Tricolored Munia	*Lonchura Malacca*	CL	R
143		Indian Silverbill	*Euodice malabarica*	RF	R
144		Scaly-breasted Munia	*Lonchura punctulata*	TF	R
145		Black-throated Munia	*Lonchura kelaati*	CL	R
146	Passeridae	House Sparrow	*Passer domesticus*	HH	R
147	Ploceidae	Baya Weaver	*Ploceus philippinus*	CL	R
148	Oriolidae	Indian Golden Oriole	*Oriolus kundoo*	TF	R
149	Dicruridae	Black Drongo	*Dicrurus macrocercus*	CL	R
150	Sturnidae	Brahminy Starling	*Sturnus pagodarum*	CL	R
151		Rosy Starling	*Sturnus roseus*	CL	R
152		Common Myna	*Acridotheres tristis*	HH	R

153	Corvidae	House Crow	*Corvus splendens*	HH	R
154		Large billed Crow	*Corvus macrorhynchos*	TF	R

Status: R= Resident, M= Migratory, LM= Local Migrant, ER = Endemic Resident, VU= Vulnerable, NT= Near-threatened.
Habitat: FW= Fresh water, BR- Bank of river, PW= Polluted water, GL= Grassland, HH= Human habitation, CL= Cropland, M= Marsh, S= Scrub, EW= Electric wire in fields, TF= Tree in field, FCL= Flying in cropland, RF= Road in field.

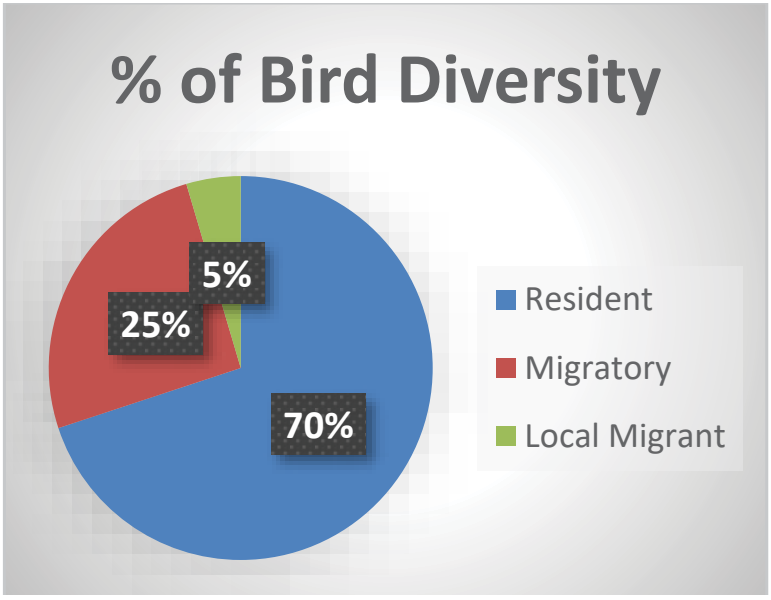


Chart 1. Bird diversity at Malwadi No.1

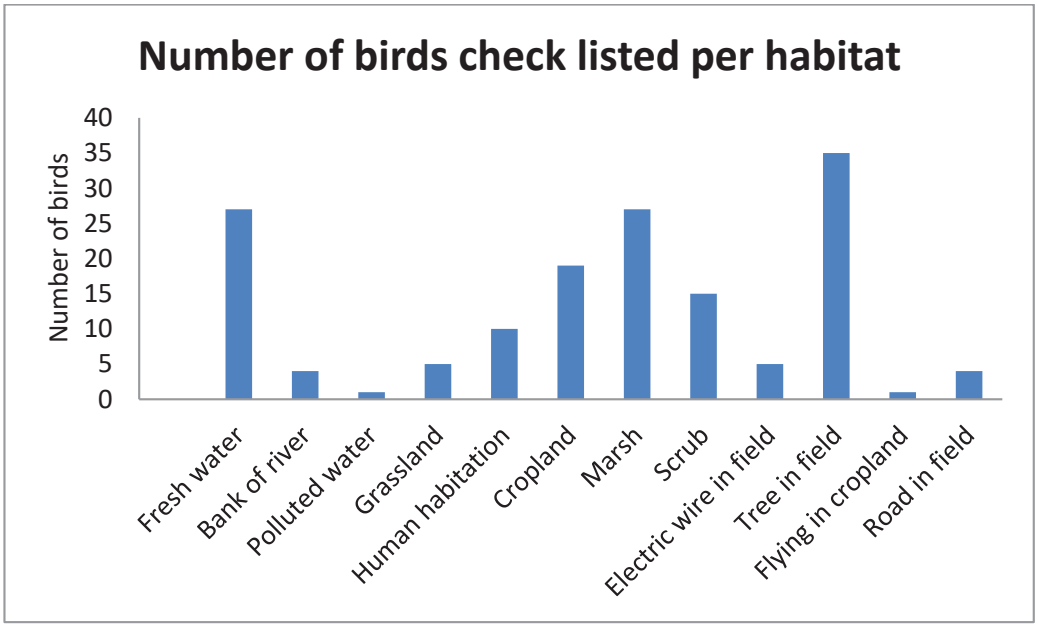
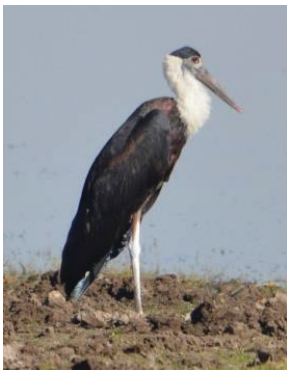
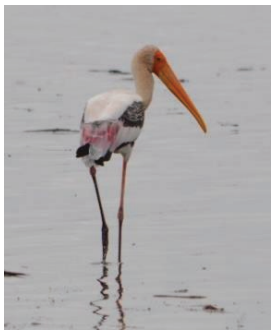
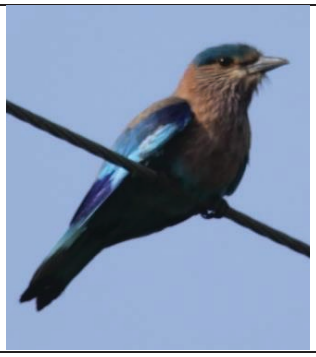


Chart 2. Representation of number of birds per habitat

Plate 4. Photographs of some birds recorded during the study

			
Wooly-necked Stork	Painted Stork	Black-headed Ibis	Greater Flamingo
			
Bar-headed Goose	Western Black-tailed Godwit	Black-winged Stilt	Wood snipe
			
Indian Roller	Jerdon's Nightjar	Eurasian Hoopoe	Common Hawk-Cuckoo
			
Blue-throat	Short-toed Snake Eagle	Scaly-breasted Munia	White-spotted Fantail

Conflict of Interest

The authors declare that they have no conflict of interest.

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Recent Photographic Record of Indian Dhole *Cuon alpinus* from Satpuda Hill Ranges of Jalgaon District, Maharashtra

Laxminarayan Sonawane[*1], Prasad Sonawane[*2], Aman Gujar[*3]

[*](Vanyajeev Sanrakshan Sanstha, Jalgaon, 425001)
rahulsonawane1727@gmail.com[1], polarisrahul@gmail.com[2], amangujar@gmail.com[3]

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Photos : Prasad Sonawane

Key words- Indian Dhole, Wild dogs, Satpuda, Jalgaon.

Abstract

Satpuda hills of Jalgaon district are an important part of Satpuda Tiger Corridor, which extends from Melghat Tiger Reserve, Amravati in the east to the Shulpaneshwar Sanctuary, Gujarat in the west. The Satpuda Tiger Landscape of Jalgaon district shelters wide range of mammalian fauna including Tiger *Panthera tigris*, Leopard *Panthera pardus*, Indian Gaur *Bos gaurus*, Sloth Bear *Melursus ursinus* etc. Present note is the recent photographic evidence of Indian Dhole *Cuon alpinus* (Pallas, 1811) from Satpuda hills of Jalgaon district after a gap of two decades.

Introduction

Jalgaon district is situated in the northernmost part of Maharashtra state. Jalgaon district includes varied topographical features and landscapes, consisting of hills and forests, stretches of barren plains, low rolling rocky hills and densely gullied topography near river banks. The northern boundary of the district is marked by the longitudinal depression of the Aner River and its eastern by the Mamat tributary of the Suki River. Jalgaon district has three reserve forests, Yawal Wildlife Sanctuary, Gautala-Autram Ghat Sanctuary and Muktai-Bhavani Conservation Reserve Zone. Tiger *Panthera tigris*, Leopard *Panthera pardus*, Indian Gaur *Bos gaurus* and Sloth Bear *Melursus ursinus*, among others, occur in these reserves indicating a healthy ecosystem. The present sighting of Indian Dhole *Cuon alpinus* from Satpuda hills of Jalgaon district justifies the importance of the Wadhoda-Aner tiger corridor which is essential for the movement of wildlife of the region, and important for connecting the Satpuda landscape ranging from Melghat Tiger Reserve, Amravati to the Shulpaneshwar Wildlife Sanctuary in Gujarat.

Result and discussion

During the biodiversity survey on 17th May 2021, at around 6.45 pm, while returning from Yawal Wildlife Sanctuary, Prasad Sonawane noticed two dog-like animals resting in the stream running parallel to Waghzeera-Ambapani Road. As it was very unusual for us to see dogs in deep forest, we observed the animals carefully. While photographing, it became clear that this was a pair of Indian Dhole *Cuon alpinus*. 12 photos and 4 videos of Wild dogs were obtained. Indian Dholes sighted at the border of Yawal Wildlife Sanctuary and Yawal Forest Division were reddish brown in coloration with short legs, a bushy tail, and a short, thick muzzle as compared to the Wolf and the Jackal. Ears were triangular, relatively larger and lined with white fur inside. The tail was russet at its base, otherwise fully black. The legs were thin and long, due to which it is referred as 'catlike canid' (Menon, 2014). In the present sighting only 2 Dholes were observed. Photographs, videos and precise location were recorded using GPS enabled digital camera and observations were made using binoculars. Photographs and videos of Indian Dhole were submitted to relevant forest departments.

Conclusion

Indian Dholes are categorized as endangered in IUCN's red data book. They inhabit dry and moist deciduous forests of Maharashtra and have been recorded from Ratnagiri, Kolhapur, Amravati, Nanded, Bhandara, Chandrapur and some other districts. Review of literature published on mammalian fauna of Jalgaon district shows presence of Indian Dholes till 2001 [Campbell, 1866, Uzagare, 2013(without photographic evidence)]. No subsequent records of this species were found (Chopda et al, 2019) from Jalgaon district. Hence, the present sighting of Indian Dholes in Satpuda hills of Jalgaon district is an important recent photographic record of this endangered species after a gap of approximately 20 years from Jalgaon district. Finding of this rare and endangered species is important for strengthening our demand for declaration of Wadhoda-Aner Tiger Corridor and conservation and protection of forests and wildlife of Jalgaon district.

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The authors are highly obliged to Dr. Sudhakar Kurhade, Professor of Zoology, Ahmednagar, for his kind guidance. They are also thankful to Shri. Anil Anjankar, (CF, wildlife, Nashik) and Shri. Digambar Pagar (CF, Territorial Forest, Dhule) for their consistent support and encouragement towards exploring biodiversity of Satpuda hills. They express gratitude to Ravindra Phalak, Aman Gujar, Chetan Bhavsar, Balkrishna Devre, Ravindra Sonawane, Vasudev Vadhe for participation in field visits.

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First record of the Owlet Moth *Bastilla simillima* from Maharashtra, Mumbai (Erebidae: Aganainae: Poaphilini).

Javed Ahmed[1]*, Chris Cathrine[2], Krishna Mohan [2,3], Bhushan Jadhav[4].

[1]*Corresponding Author: Jai Gopi Krishna CHSL, 'A' Wing, Flat No. 102; 1, Patil Wadi, Govandi East, Mumbai, Maharashtra 400088, India
email - curiocritters@gmail.com
[2]Office 2 and 3, Craigarnhall, Bridge of Allan, Stirling, FK9 4NG, Scotland
email - chris.cathrine@caledonianconservation.co.uk
[3]Prabhu Hospital, Hospital Cross Road, Moodbidri, Karnataka, 574227, India,
email - drkrishi@gmail.com
[4]A-4, Plot no. 82, Aasra Co-operative Housing Society, Near Swami Vivekanand School, Gorai-1, Borivali (West), Mumbai 400091, India.
email - bhushanjadhav7604@gmail.com

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While the Erebid moth *Bastilla simillima* (Guenée, 1852) is known to occur in India (Sivasankaran et al., 2012), it has only been recorded from a handful of states in the country, of which formally published, peer-reviewed reports, are even scantier. From Western India, it has only been reported from the states of Goa, and Gujarat (Gurule & Brookes, 2021; Sondhi et al., 2021), and none of the major moth surveys conducted in the state of Maharashtra, list the species (Gurule et al., 2010; Shubhalaxmi et al., 2011; Gurule & Nikam, 2011; Gurule, 2013; Gurule & Nikam, 2013; Gadhikar et al., 2015; Nimbalkar & Shinde, 2015; Kalawate, 2018; Pathre et al., 2019; Pujari, 2021). We present here, the first record of the species from the state of Maharashtra, Mumbai.

A single imago attracted to artificial light, indoors, on 11 AUG 2021 (20:17 hrs.), in Eastern Mumbai (Govandi East), was photographed, and subsequently identified as *B. simillima*, based on the description provided by Hampson (1894), namely: antemedial line curved, with dark suffusion inside; postmedial line with dark suffusion instead of a dark patch inside it, and with two slight angles beyond the cell. Apical streak slight. Submarginal line dentate, indistinct. Hind wing with the cilia pale below the apex (Figure 1**).**

Furthermore, this description, and the corresponding record shot, was found to be in agreement with photographs of *B. simillima* posted to the 'Moths of India' website (Sondhi et al., 2021), from which further distribution records of the species in India were gathered,

namely, West Bengal, in Eastern India; Tamil Nadu, in South India; Karnataka, in Southwest India; Andhra Pradesh, in the South-eastern coastal region of India, to which is added the present record from Mumbai, Maharashtra, in Western India (Figure 2).

Globally, in addition to India, *B. simillima* is known to occur in Bangladesh, China, Taiwan, and Indonesia (GBIF Secretariat, 2021). Not much is known about the natural history of the species, except that larvae feed on *Phyllanthus* L. *spp*. (Holloway & Miller, 2003), and that it is parasitized by the braconid wasp *Xiphozele compressiventris* Cameron, 1906 (Achterberg, 2008). Further studies are needed to better understand the ecology, and distribution of this species.

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This paper is fondly dedicated to the memory of our beloved late-great friend, Dr. Krishna Mohan: physician, surgeon, photographer, educator, and above all, brilliant naturalist, and scientist - lost, but never forgotten. Javed Ahmed would like to thank Caledonian Conservation Ltd (Scotland), for their generous financial aid. Ms. Rajashree Khalap, and Sunjoy Monga are also thanked for their constant encouragement, and support. All images copyright Javed Ahmed/curiocritters/The Urban Bestiary Project/Wild Megapolis project.

Figure 1

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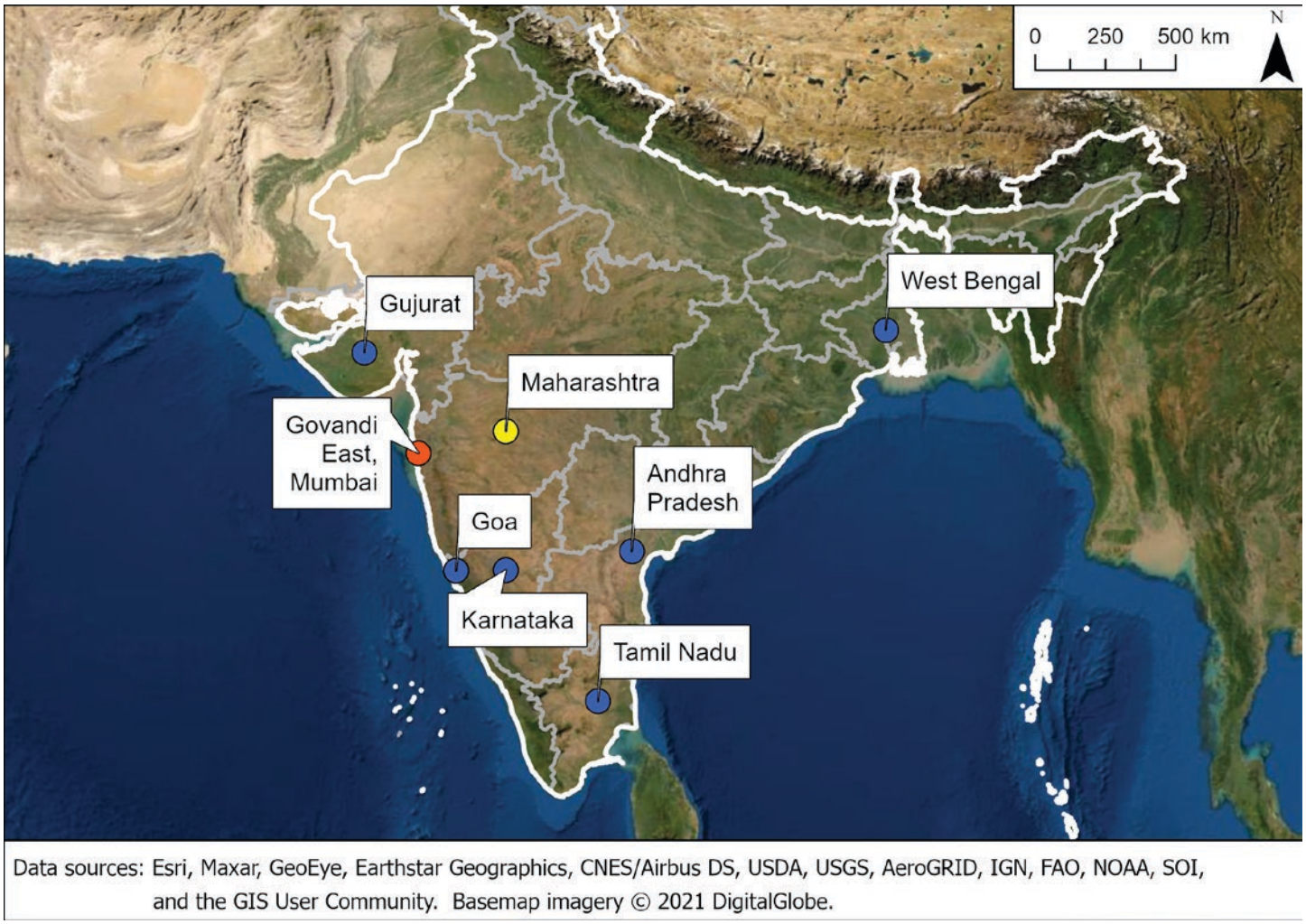

Figure 2

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Record of Painted Storks *Mycteria Leucocephala* from Kabeerdham, Chhattisgarh

Alok Kumar Chandrakar*, S. S. Dhuria

Department of Forestry, Wildlife & Environmental Sciences,
Guru Ghasidas Vishwavidyalaya, Bilaspur, Chhattisgarh, India.
E-mail: alokanand1234@gmail.com

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Abstract

We report the rare sighting record of Painted Stork (*Mycteria leucocephala*) in Kabeerdham region, Chhattisgarh. A flock of six adult Painted Storks was observed in the reservoir of Newari village near Kawardha city on 12 July 2021.

Key words: Painted Stork, Kabeerdham, Chhattisgarh, India.

Painted Stork is a near threatened species (Chandrakar and Dhuria 2021) in IUCN (International Union for Conservation of Nature) Red List and widely distributed in the Indian subcontinent and parts of South East Asia (BirdLife International 2016). Painted Storks are often restricted to shallow freshwater wetlands and marshes. They have also been observed in flooded agricultural fields and seepage ponds in the Delhi region of India (Urfi and Kalam 2007).

Fig. 1- Flock of Painted Storks

Fig. 2- Foraging behaviour of Painted Storks

Fig. 3- A flock of six adult Painted Storks taking rest

Newari reservoir is a good birding place near Kawardha city of Kabeerdham district. Chhattisgarh. It is about 5 km away from the district headquarter and is situated at 22°2' 18.7506" N latitude and 81°15' 25.5558" E longitude near Newari village. It provides water for irrigation to the surrounding Newari, Joratal and Singhanpuri villages. During regular bird watching a flock of six adult Painted Storks (*Mycteria leucocephala*) was recoded on 12 July 2021 at 9 AM in a sunny weather. The morphological features and behaviour were observed using binocular and photographs were taken using digital camera. (Ali 2002; Grimmett et. al. 2016).

Their behaviour was observed for 45 minutes. In order to catch prey, the storks employed a mode of foraging known as tactile foraging, coupled with foot stirring for flushing out inactive or hidden prey. Tactile foraging involves a bird holding its open beak underwater and waiting for movement near the bill before clamping it shut on the prey (Urfi and Kalam 2007). Painted Storks are known to feed on fish, insects, crustaceans, amphibians and reptiles (Urfi and Kalam 2007).

They are locally migratory and when the site was revisited at the evening and the next morning, we could not see the birds. The present sighting was the first sighting of this bird from Kabeerdham (formally known as Kawardha) region in last three and half decades and second sighting in the district. Painted Stork was once sighted in Dashrangpur village of Kabeerdham district on 06 January, 1985 (e-Bird 2021: Checklist No. S44317170). Other than this no documented record of this bird is available in the region.

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S. No.	Name & Designation	Area of Specialization	Address	Telephone No.	Email
9	**Dr. Yogesh Shouche** Scientist 'G'	Microbial ecology, Microbial molecular taxonomy and biodiversity	National Centre for Microbial Resource, National Centre for Cell Science, Ganeshkhind Pune-411007	+91-020-25329027	yogesh@nccs.res.in
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11	**Suruchi Pande** Head, Dept. Of Ethno-Ornithology, OENSL -Ela Foundation & MES, A.G.College Campus	Ethno-Ornithology	C-9, Bhosale Park, Sahakarnagar No. 2 Pune 411009	+91-020-9881144651	suruchipande@gmail.com
12	**Gombobaatar Sundev** Professor, Department of Biology, National University of Mongolia	Ornithology Taxonomy	Director, Mongolian Ornithological Society P.O.Box 537, Ulaanbaatar 210646A, Ikh surguuli gudamj-1, Ulaanbaatar, MONGOLIA. Tel: Fax: 976-11-320159 E-mail	976-99180148; 976-90112244 (mob.); 976-11-323970 (off.)	info@mos.mn; gomboo@num.edu.mn
13	**Hemant Ghate** Professor	Entomology	Prof. Emiritus, Department of Zoology, Modern College of Arts, Science and Commerce, Off J.M. Road, Pune, 411005	+91-020-9960629667	hemantghate@gmail.com

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